THE AMERICAN

ARTIST'S MANUAL,

OR

DICTIONARY OF PRACTICAL KNOWLEDGE

IN THE

APPLICATION OF PHILOSOPHY

TO

THE ARTS AND MANUFACTURES.

Selected from the most complete European Systems,

WITH

ORIGINAL IMPROVEMENTS

AND

APPROPRIATE ENGRAVINGS.

ADAPTED TO

THE USE OF THE MANUFACTURERS OF THE UNITED STATES.

BY JAMES CUTBUSH.

IN TWO VOLUMES—VOL. II.

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THE

ARTIST'S MANUAL;

OR,

DICTIONARY OF PRACTICAL KNOWLEDGE.

M.

MACHINE, simple and compound. See MECHANICS.

MACHINES, principles of their construction. See MECHANICS.

MACERATION. The steeping of a body in a cold liquor. It does not differ from DIGESTION, excepting that the term is never used when the temperature of the mass is raised beyond that of the surrounding air. It is obvious, that maceration, or digestion without heat, must be used in all requisite cases wherein the fugitive nature of some of the component parts of the subject of examination, or its disposition to become changed by heat, renders the process of digestion, assisted by heat, unfavourable to the intended process.

MADDER, a substance very extensively employed in dyeing, is the root of the rubia tinctorum.

Although madder will grow both in a stiff clayey soil, and in sand, it succeeds better in a moderately rich, soft, and somewhat sandy soil: it is cultivated in many of the provinces of France, in Alsace, Normandy, and Provence: the best of European growth is that which comes from Zealand.

There are various methods of cultivating and preparing madder, and many treatises have been written on the subject: that of Mr. Duhamel may be consulted, but more particularly that of Mr. le Pileur d'Apligny, published at the end of his Art of Dyeing Threads and Cotton Stuffs. See also ARCHIVES OF USEFUL KNOWLEDGE.

The madder prepared for dyeing is distinguished into different sorts: that obtained from the principal roots is called crop madder; the non crop is that which is produced from the stalks, which by being buried in the earth are transformed into roots, and are called layers: each of these kinds is sub-divided into fine, bale, bunch, and short, or mull.

When the madder roots are gathered, the layers are separated from them, to form the non crop; and such of the fibres of the roots as do not exceed a certain degree of thickness are added, as are also those roots which are too thick, and which contain a great deal of heart or ligneous part: the best roots are about the thickness of a goose quill, or at most of the little finger; they are semi-transparent, and of a reddish colour; they have a strong smell, and the bark is smooth.

When the madder is gathered and picked, it must be dried, in order to render it fit for grinding and being preserved; in warm climates it is dried in the open

air; in Holland, by means of stoves, which sometimes communicate too great a degree of heat, and change its colour by an admixture of fuliginous particles. Hellot ascribes the superiority of the madder which comes from the Levant to the circumstance of its having been dried in the open air.

After the root has been dried, it must be shaken in a sack, or lightly beaten on a wooden hurdle, after which it must be sifted or winnowed. In this way the earth is separated from it, and the billon is removed, a name by which the small roots and their bark are distinguished. After this, nothing remains but to reduce it to powder, which may be done by a vertical millstone, or by pestles, or even by a common snuff-mill.

All the parts of the madder cannot be powdered with equal facility; the outer bark and ligneous parts are more easily pounded than the parenchymatous parts. Advantage is taken of this circumstance in order to separate those parts, as they do not all give the same colour; the outer bark, as well as the wood within, affords a yellowish colour, which spoils the red we wish to obtain. This separation established the distinction of madder into robée, mirobée, and courte. After the first operation of the mill, the madder is passed through a sieve, with a cover fitted to it, by which means what is called the short madder, which is intended for tan and modoré colours, is obtained; the remainder is again ground and sifted, and thus the mi-robée is obtained; and a third operation affords the robée. The madder thus powdered is to be preserved in a dry place, well packed in casks, where from its natural unctuosity it concretes into lumps.

Mr. Beckmann agrees with Mr. Hellot in opinion, that the heat of stoves injures the colour of madder, and that it would be better to dry it in the air only, the effect of which might be promoted by various means. He finds that common ovens, immediately after the bread is taken out, may be used instead of the Dutch stoves, when artificial heat is to be employed. Mr. d'Ambourney has made some interesting experiments upon madder; he thinks, that the fresh root may be used in dyeing with as much advantage as the powdered. He observed that four pounds of the fresh are equal to one of the dried, although in the drying seven-eighths of its weight are lost; the expense of stoving, packing, and sifting is saved; and it is only necessary to take care, that the roots be thoroughly washed in a current of water as soon as they are taken out of the ground; they are afterward cut into pieces, and bruised by the vertical mill See Dyeing.

MADDER LAKES. See Colour Making.

MADDER REDS. See Dyeing.

MADDER RED, of Papillon.—Some years ago a Mr. Papillon set up a dye-house for this red at Glasgow; and in 1790 the commissioners for manufactures in Scotland paid him a premium, for communicating his process to the late Prof. Black, on condition of its not being divulged for a certain term of years. The time being expired, it has been made public, and is as follows:

Step. I.—For one hundred pounds of cotton, you must have 100 lb. of Alicant barilla, 20 lb. of pearl-ashes, 100 lb. of quick lime.

The barilla is to be mixed with soft water in a deep tub, which has a small hole near the bottom of it, stopped at first with a peg. This hole is to be covered in the inside with a cloth supported by two bricks, that the ashes may be prevented from running out at it, or stopping it up, while the ley filters through it. Under this tub must be another, to receive the ley, and pure water is to be passed repeatedly through the first tub, to form leys of different strength, which are kept separate until their strength is examined. The strongest required for use must float an egg, and is called the ley of six degrees of the French hydrometer. The weaker are afterward brought to this strength by passing them through fresh barilla; but a certain quantity of the weak, which is of two degrees of the above hydrometer, is reserved for dissolving the oil, the gum, and the salt, which are used in subsequent parts of the process. This ley of two degrees is called the weak barilla liquor; the other the strong.

Dissolve the pearl ashes in ten pails, of four gallons each, of soft water, and the lime in fourteen pails.

Let all the liquors stand till they become quite clear, and then mix ten pails of each.

Boil the cotton in this mixture five hours, then wash it in running water, and dry it.

Step. II. Bain bis, or Gray steep.—Take a sufficient quantity (ten pails) of the strong barilla water in a tub, and mix with it two pailfuls of sheep's dung; then pour into it two quart bottles of sulphuric acid, one pound of gum arabic, and one pound of sal ammoniac, both previously dissolved in a sufficient quantity of weak barilla water; and, lastly, twenty-five pounds of olive oil, previously dissolved, or well mixed with two pails of the weak barilla water.

The materials of this steep being well mixed, tread down the cotton into it until it is well soaked; let it steep twenty-four hours, then wring it hard and dry it.

Steep it again twenty-four hours, and again wring and dry it.

Steep it a third time twenty-four hours, after which wring and dry it; and, lastly, wash it well and dry it.

Step. III. The white steep.—This part of the process is precisely the same with the last in every particular, except that the sheep's dung is omitted in the composition of the steep.

Step. IV. Gall steep.—Boil twenty-five pounds of bruised galls in ten pails of river water, until four or five are boiled away; strain the liquor into a tub, and pour cold water on the galls in the strainer to wash out of them all their tincture.

As soon as the liquor is become milk-warm, dip your cotton hank by hank, handling it carefully all the time, and let it steep twenty-four hours. Then wring it carefully and equally, and dry it well without washing.

Step. V. First alum Steep.—Dissolve twenty-five pounds of Roman alum in fourteen pails of warm water, without making it boil: scum the liquor well, add two pails of strong barilla water, and then let it cool until it is lukewarm.

Dip your cotton, and handle it hank by hank, and let it steep twenty-four hours; wring it equally, and dry it well without washing.

Step. VI. Seccond alum Steep.—This is in every particular like the last; but after the cotton is dry, steep it six hours in the river, and then wash and dry it.

Step. VII. Dyeing steep—The cotton is dyed by about ten pounds at once, for which take about two gallons and a half of bullock's blood, mix it in the copper with twenty-eight pails of milk-warm water, stir it well, add twenty-five pounds of madder, and lastly stir all well together. Then, having beforehand put the cotton on sticks, dip it into the liquor, and move and turn it constantly one hour, during which, gradually increase the heat until the liquor begins to boil at the end of the hour. Then sink the cotton, and boil it gently one hour longer; and lastly wash it and dry it.

Take out so much of the boiling liquor, that what remains may produce a milk-warm heat with the fresh water with which the copper is again filled up, and then proceed to make up a dyeing liquor, as above, for the next ten pounds of cotton.

Step. VIII. The fixing steep.—Mix equal parts of the gray steep liquor and of the white steep liquor, taking five or six pails of each. Tread down the cotton into this mixture, and let it steep six hours; then wring it moderately and equally, and dry it without washing.

Step. IX. Brightening steep.—Ten pounds of white soap must be dissolved very carefully and completely in sixteen or eighteen pails of warm water; if any little bits of the soap remain undissolved, they will make spots in the cotton Add four pails of strong barilla water, and stir it well. Sink the cotton in this liquor, keeping it down with cross sticks, and cover it up; boil it gently two hours, then wash it and dry it, and it is finished. See Dyeing.

MAGNESIA, or Magnesia Alba. See Earths.

The artificial carbonated magnesia (the common magnesia, or magnesia alba of the shops,) is prepared by decomposing the sulphat of magnesia or Epsom salt with common carbonat of potash. To succeed perfectly in this preparation several precautions are requisite. The following is the process usually given. Take a pound of sulphat of magnesia dissolved in about five pints of water, add to this a pound of good purified pearlash, or prepared carbonated potash, dissolved in a like quantity of water, and boil them for some minutes. A copious white precipitate is produced on the moment of mixture, which renders the whole mass extremely thick. Strain it while hot through linen (not paper) and wash the precipitate left on the strainer by repeated affusions of a very large quantity of boiling water, till it comes away tasteless. The precipitate gently dried becomes a perfectly white extremely light tasteless powder, which is common magnesia.

A double decomposition takes place in this process, the sulphuric acid quitting the sulphat of magnesia to unite with the potash, and the magnesia uniting with the carbonic acid of the alkali employed. The sulphat of potash being a salt of very sparing solubility in water, renders it necessary to wash the precipitate so abundantly. The drying of the carbonat of magnesia is tedious, for being excessively light and spungy, it retains a large portion of water, which cannot be separated by filtration. In the manufacture in the large way, the paste of magnesia and water is spread on slabs of chalk, which absorbs the water eagerly and much hastens the drying.

Common carbonat of magnesia consists of carbonic acid, water and magnesia in somewhat varying proportions. By being calcined for some time in a red heat, both the water and carbonic acid are expelled, and the entire loss by calcination is on an

average about 55 per cent. On the other hand, this carbonat when added to an acid, effervesces violently, but only parts with its carbonic acid in the effervescence, and this loss is about 34 per cent., consequently the constituent parts of 100 parts of the common carbonat of magnesia will be, when dried in a gentle heat,

Magnesia - -	45
Carbonic acid -	34
Water - - -	21
	100

The quantity of alkali commonly used in obtaining magnesia is more than is necessary to decompose the magnesian sulphat, and probably one-fourth or one-fifth less would be sufficient.

Common magnesia is scarcely at all soluble in pure water, but with an additional quantity of carbonic acid its solubility increases largely. Hence in making common magnesia it is adviseable to boil the ingredients on mixture, by which a considerable quantity of loosely combined carbonic acid is expelled, which otherwise would unite with part of the magnesia, render it soluble in water, and it would be carried away in the washings. Hence the more the alkali employed is saturated with carbonic acid (beyond the exact dose necessary for the precipitated magnesia) the less will be the product left on the filter, unless the boiling be continued a proper time.

For obtaining pure magnesia, or magnesia free from carbonic acids, see EARTHS.

Dr. Bruce has discovered this earth in New Jersey.

MAGNETIC IRON ORE. See IRON.

MAGNET, natural. See MAGNETISM.

MAGNET, artificial. See MAGNETISM.

MAGNETISM.—The natural magnet or loadstone, is a hard mineral body of a dark-brown, or almost black colour, and when examined, is found to be an ore of iron. It is found in various countries, generally in iron mines, and of all sizes and forms.

This singular substance was known to the ancients; and they had remarked its peculiar property of attracting iron, though it does not appear that they were acquainted with the wonderful property which it also has, of turning to the pole when suspended, and left at liberty to move freely.

Upon this remarkable circumstance does the mariner's compass depend, an instrument which gives us such infinite advantages over the ancients. It is this which enables the mariners to conduct their vessels through vast oceans out of the sight of land, in any given direction: and this directive property also guides the miners in their subterranean excavations, and the traveller through deserts otherwise impassable.

It is not precisely known when and by whom this directive property of the magnet was discovered. The most probable accounts seem to prove, that it was known early in the 13th century; and that the person who first made mariner's compasses, at least in Europe, was a Neapolitan of the name of Flavio, or John de Gioja, or Giova, or Gira.

Before that period, mariners scarcely ever ventured out of sight of land, and in the longest voyages they contented themselves with going round the coasts, making by that means their journey much longer. In the night, and when necessity obliged them to lose sight of the shore, their only guides were the heavenly bodies, and when these were obscured by clouds, they were absolutely without resource.

While navigation continued so dangerous, men never would have ventured upon such voyages as those to the West Indies, America, and the South Seas; and probably the existence of those countries would have been still unknown to us.

We cannot, therefore, think too highly of this extraordinary instrument, which has so much enlarged our stock of knowledge, and procured for us so many new enjoyments.

The natural loadstone has also the quality of communicating its properties to iron and steel; and when pieces of steel properly prepared are touched, as it is called by the loadstone, they are denominated artifical magnets.

These artificial magnets are even capable of being made more powerful than the natural ones, and as they can be made of any form, and are more convenient, they are now universally used; so that the loadstone or natural magnet is only kept as a curiosity.

All magnets, whether natural or artificial, are distinguished from other bodies by the following characteristic properties, which appear to be inseparable from their nature: so that no body can be called a magnet, unless it be possessed of all these properties.

1. A magnet attracts iron.

2. When a magnet is placed so as to be at liberty to move freely in every direction, it turns so that its ends point towards the poles of the earth, or very nearly so:

and each end always points to the same pole. This is called the polarity of the magnet: the ends of the magnet are called poles, and they are called north and south poles of the magnet, according as they point to the north or south pole of the earth. When a magnet places itself in this direction, it is said to traverse.

3. When the north pole of one magnet is presented to the south of another magnet, these ends attract each other; but if the south pole of one magnet be presented to the south pole of another, or the north pole of one to the north pole of another, these ends will repel each other.

From these criteria, it is easy to determine the names of the poles of a magnetical bar, by applying it near a suspended magnet whose poles are known.

4. When a magnet is situated, so as to be at liberty to move itself with sufficient freedom, its two poles do not lie in a horizontal direction, but it generally inclines one of them towards the horizon, and of course it elevates the other pole above it. This is called the inclination, or dipping of the magnet.

5. Any magnet may, by proper methods, be made to impart these properties to iron or steel.

A plane, perpendicular to the horizon, and passing through the poles of a magnet, when standing in their natural direction, is called the magnetic meridian; and the angle which the magnetic meridian makes, with the meridian of the plane where the magnet stands, is called the declination of the magnet at that place.

Of Magnetic Attraction and Repulsion.—When a piece of iron is brought within a certain distance of one of the poles of a magnet, it is attracted by it; and if the iron be at liberty to move, it adheres to the magnet, and cannot be separated without some force. It appears at first sight, that the attraction lies only in the magnet, but experiment proves this attraction to be mutual; the iron attracting the magnet as much as the magnet attracts the iron. Place the magnet and the iron upon two separate pieces of cork, or wood, floating upon water, at a little distance from each other, and it will be found that the iron moves towards the magnet, as well as the magnet towards the iron; if the iron be kept steady, the magnet will move towards it.

This attraction is strongest at the poles of a magnet, and diminishes in proportion to the distance of any part from the poles, so that in the middle between the poles there is no attraction. This may be easily perceived by presenting a piece of iron to various parts of the surface of a magnet.

The intensity of the attractive power diminishes also, according to the distance from the magnet. If the magnet and iron touch each other, it requires a certain degree of force to separate them; if the iron be removed a little way from the magnet, an attraction will be plainly perceived, but not so powerful; and by increasing this distance the attraction will be much diminished.

The law of diminution of this attraction is not yet known. Some have imagined that it diminished in proportion to the square of the distance, others as the cube of the distance. But either from the difficulty of the subject, or on account of the experiments having been made without sufficient accuracy, the question remains yet undecided; it is only known that the attractive force decreases faster than the simple ratio of the distances.

As magnetic attraction takes place only between poles of different names, and of different magnets; that is, the north pole of one magnet attracts the south pole of another; consequently magnetic repulsion acts only between poles of the same name of different magnets. Thus, if the north pole of one magnet be opposed to the north pole of another magnet, or, if the south pole be opposed to the south pole of the other, then those magnets will repel each other, and that nearly with as much force as the poles of different names would attract each other.

But it frequently happens, that though magnets are placed with the same poles towards each other, yet they either attract each other, or shew a perfect indifference. This, at first, seems to contradict the above mentioned general law; but this difficulty is removed by the following considerations.

When a piece of iron is brought within a certain distance of a magnet, it becomes, in fact, itself a magnet, having the polarity, the attractive, and repulsive properties for other iron, &c.; that part of it which is nearest to the south pole of the magnet, becoming a north pole, and the opposite part a south pole, or vice versa, according to the end of the magnet presented.

Soft iron, when placed within the influence of a magnet, easily acquires these properties; but they last only while the iron remains in that situation, and when it is removed, its magnetism vanishes immediately. But with iron containing carbon, and particularly with steel, the case is very different; and the harder the iron or the steel is, the more permanent is the magnetism which it acquires from the influence of a magnet; but it will be in the

same proportion more difficult to render it magnetic.

If a piece of soft iron, and a piece of hard steel, both of the same shape and size, be brought within the influence of a magnet at the same distance, it will be found that the iron is attracted more forcibly, and appears more powerfully magnetic than the steel; but if the magnet be removed, the soft iron will instantly lose its acquired properties, whereas the hard steel will preserve them for a long time, having become an artificial magnet.

It appears from these facts, that there is no magnetic attraction but between the contrary poles of magnets: for the iron which is presented to the magnet, must itself become a magnet, before it is capable of being attracted. It appears, also, why a magnet has a greater attraction for soft than for hard iron, and still more for hard steel; the steel not becoming so easily magnetical as the iron, by presenting it to a magnet. This also explains why only poles of the same name repel each other: for, when the north pole of one magnet does not seem to attract or repel, or it actually attracts what was called the north pole of the other magnet, the fact is, either that the two north, or the two south poles have destroyed each other; or, that the superior force of one of the magnets has actually changed the poles of the weaker magnet, as is beyond a doubt proved by experiment.

Neither the magnetic attraction nor repulsion is in the least diminished, or at all affected by the interposition of any sort of bodies, except iron, or such bodies as contain iron.

The properties of the magnet are not affected either by the presence or by the absence of air. Heat weakens the power of a magnet, and subsequent cooling restores it, but not quite to its former degree. A white heat destroys it entirely, or very nearly so: and, hence it appears, that the powers of magnets must be varying continually. CAVALLO observes, that iron in a full red heat, or white heat, is not attracted by the magnet; but the attraction commences as soon as the redness begins to disappear.

The attractive power of a magnet may be considerably improved by hanging a weight to it, which may be gradually increased; and also by keeping it in a proper situation, viz. with its north pole towards the north, and its south pole, consequently, towards the south. On the contrary, this power is diminished by an improper situation, and by keeping too small a piece of iron, or no iron at all, appended to it.

In these northern parts of the world, the north pole of a magnet has more power than its south pole; whereas, the contrary effect has been said to take place in the southern parts.

Most probably the magnet attracts iron only; but when it is considered how universally iron is dispersed throughout nature, it is evident that a vast number of bodies must on that account be attracted by the magnet more or less forcibly, in proportion to the quantity and quality of the iron they contain. Indeed, it is wonderful to observe, what a small portion of iron will render a body subject to the influence of the magnet. However, though it must be acknowledged that every body which contains iron is in some measure attracted by the magnet, yet it does not follow that no other body can be attracted by it. A great many substances are in a very slight degree attracted, which seem to contain either no iron at all, or an exceedingly small quantity of it, extremely diffused and oxydated.

To discover this small degree of attraction, the substances should be placed upon a piece of paper, or a thin shaving of cork, which should be put to float upon water, and then the magnet should be gently approached sideways, to within one-tenth of an inch distance from the substance under trial. The following substances will in this manner, be found to be in some measure, affected by the magnet, viz. most metallic ores, especially after having been exposed to a fire. Zinc, bismuth, and particularly cobalt, are generally attracted. The calcareous is the least attractable of the earths, and the siliceous is the most frequently attracted. The ruby, the chrysolite, the tourmalin, and the opal are attracted. The emerald, and particularly the garnet, are not only attracted, but frequently acquire permanent magnetism. Amber, and many other combustible minerals are attracted, especially after combustion. The ashes of most animal and vegetable substances, are attracted; also soot, and the dust which floats in the atmosphere, are often attracted by the magnet.

Cavallo discovered, that if most specimens of brass which shew no attraction towards the magnet, be hammered, they will, in that hardened state (produced by the hammering) be attracted. The same piece of brass will no longer be attracted, after being softened in the fire: a second hammering will again render it attractable, and so on repeatedly. Most of the native grains of platina have the same property.

In the examination of the magnetism of

various bodies, it may be of importance to know the degrees of magnetism, as discoverable by experiment, which are the following: the weakest is, when a body floating on water slowly follows a strong magnet, held almost touching it; the next is, when a magnet can repel as well as attract the body; a still stronger degree is, when the body conforms its position to that of the magnet held over it; the fourth is, when the body, left to itself, assumes a particular position, and returns to it when disturbed; the fifth is, when the body, taken out of the water, and brought near a magnet, causes it to deviate from the magnetic meridian. All stronger degrees of magnetism may be observed by less delicate methods.

Of the Polarity of the Magnet.—Every magnet has a south and a north pole, which are at opposite ends; and a line drawn from one to the other, passes through the *centre* of the magnet. Here it must not be understood, that the polarity of a magnet resides only in two points of its surface, for in reality, it is the one half of the magnet that is possessed of one kind of polarity, and the other half of the other kind of polarity: the poles then, are those points in which that power is the strongest.

The line drawn from one pole to the other, is called the axis of the magnet, and a line formed all round the surface of the magnet, by a plane which divides the axis into two equal parts, and is perpendicular to it, is called the *equator* of the magnet.

It is the *polarity* of the magnet that renders it so useful to navigators. When a magnet is kept suspended freely, so that it may turn north and south, the pilot, by looking at the position of it, can steer his course in any required direction. Thus, if a vessel is steered towards a certain place which lies exactly westward of that from which it set out, the navigator must direct it so, that its course may be always at right angles, with the direction of the magnetic needle of his compass, keeping the north end of the magnet on the right hand side, and of course, the south end on the left hand side of the vessel; for as the needle points north and south, and the direction is east and west, the intended course of the vessel is exactly perpendicular to the position of the magnet A little reflection will shew how the vessel may be steered in any other direction.

An *artificial magnet* fitted up in a proper box, for the purpose of guiding the direction of a traveller, is called a *magnetic needle*, and the whole together, is called the *mariner's compass.*

Although the north pole of the magnet in every part of the world, when suspended, points towards the northern parts, and the south pole towards the southern parts, yet its ends seldom point exactly towards the poles of the earth. The angle in which it deviates from due north and south, is called the *angle of declination*, or the *declination of the magnetic needle*, or the *variation of the compass;* and this declination is said to be east or west, according as the north pole of the needle is eastward or westward of the astronomical meridian of the place.

This deviation from the meridian is not the same in all parts of the world, but is different in different places, and it is even continually varying in the same place. For instance, this declination is not the same in London as at Paris, or as in India; and the declination in London, or in any other place, is not the same at this time as it was some years ago. This declination from the meridian is so variable, that it may be observed to change, even in one or two hours time; and this is not owing to the construction of the magnetic needle, for in the same place, and at the same time, all true magnetic needles point the same way.

The declination from the meridian, and the variation of this, in different parts of the world, is very uncertain, and cannot be foretold: actual trial is the only method of ascertaining it. This circumstance forms a great impediment to the improvement of navigation. It is true, that great pains have been taken by navigators and other observers, to ascertain the declination in various parts of the world, and such declinations have been marked in maps, charts, books, &c; but still, on account of the constant change to which this variation is liable, these can only serve for a few years; nor has the law of this variation or fluctuation been yet discovered, though various hypotheses have been formed for that purpose. When the variation was first observed, the north pole of the magnetic needle declined eastward of the meridian of London; but it has since that time been changing continually towards the west; so that in the year 1657 the magnetic needle pointed due north and south. At present, it declines about $24\frac{1}{2}^{\circ}$ westward, and it seems to be still advancing towards the west.

Before volcanic eruptions and earthquakes, the magnetic needle is often subject to very extraordinary movements.

It is also agitated before and after the appearance of the aurora borealis.

Of the Magnetic Inclination, or Dip of the Needle.—If a needle which is accu-

rately balanced, and suspended so as to turn freely in a verticle plane, be rendered magnetical, the north pole will be depressed, and the south pole elevated above the horizon: this property is called the *inclination, or dip of the needle*, and was discovered by Robert Norman, about the year 1576.

To illustrate this, take a globular magnet, or, what is more easily procured, an oblong one, and place it horizontally upon a table: then take another small oblong magnet, and suspend it by means of a thread, tied to its middle, or centre of gravity, so that it will remain in an horizontal position, when not disturbed by the vicinity of iron, or other magnets. Now bring this small magnet held by the thread, just over the middle of the large magnet, and within two or three inches of it; the former will turn its south pole towards the north pole of the large magnet, and its north pole towards the south pole of the large one.

It will be also noticed, that the small magnet, whilst kept just over the middle of the large one, will remain parallel to it; for since the poles of the small magnet are equally distant from the contrary poles of the large magnet, they are equally attracted; but if the small magnet be brought a little nearer to one end than to the other of the large magnet, then one of its poles, namely, that which is nearest to the contrary pole of the large magnet, will be inclined downwards, and of course, the other pole will be elevated above the horizon. This inclination, it is evident, must increase according as the small magnet is placed nearer to one of the poles of the large one, because the attraction of the nearest pole will have more power upon it. If the small magnet be brought just opposite to one of the poles of the large one, it will turn the contrary pole towards it, and will place itself in the same straight line with the axis of the large magnet.

This simple experiment will enable the reader to comprehend easily the phenomena of the magnetic inclination, or of the dipping needle, upon the surface of the earth; for it is only necessary to imagine that the earth is a large magnet (as in fact it appears to be), and that any magnet, or magnetic needle commonly used, is the small magnet employed in the above-mentioned experiment; for, supposing that the north pole of the earth is possessed of a south magnetic polarity, and that the opposite pole is possessed of a north magnetic polarity, it appears evident, and it is confirmed by actual experience, that when a magnet, or magnetic needle, properly shaped and suspended, is kept near the equator of the earth, or, more properly speaking, near the magnetic equator of the earth (since neither the magnetic equator, nor the magnetic poles of the earth, coincide with its real equator and poles), it must remain in an horizontal situation: if the magnet be removed nearer to one of the magnetic poles of the earth, it must incline to one of its extremities, namely, that which is possessed of the contrary polarity; and this inclination must increase in proportion as the needle recedes from the magnetic equator of the earth. Lastly, when the needle is brought exactly over one of the magnetic poles of the earth, it must stand perpendicular to the horizon of that place.

A magnetical needle constructed for the purpose of shewing this property, is called a dipping needle, and its direction in any place is called the magnetical line. When it was said above, that the north pole of the earth possessed south polarity, it was only meant that it had a polarity contrary to that end of the magnetic needle which is directed towards it.

If the geographical poles of the earth (that is, the ends of its axis), coincided with its magnetic poles; or even if the magnetic poles were constantly at the same distance from them, the inclination of the needle, as well as its declination, would always be the same; and hence, by observing the direction of the magnetic needle in any particular place, the latitude and longitude of that place might be ascertained; but this is not the case, for the magnetic poles of the earth do not coincide with its real poles, and they are also constantly shifting their situations; hence the magnetic needle changes continually and irregularly, not only in its horizontal direction, but likewise in its inclination, according as it is removed from one place to another, and also while it remains in the very same place.

This change of the dip in the same place, however, is very small. In London, about 1576, the north pole of the dipping needle stood 71° 50″ below the horizon; and in 1775, it stood at 72° 3′ the whole change of inclination, during so many years, amounting to less than a quarter of a degree.

The Magnetic Touch, or communicated Magnetism.—It has been already shewn, that when a piece of iron comes sufficiently near to a magnet, it becomes itself a magnet; and that this magnetism is more easily communicated to, but, at the same time, more easily lost, by soft iron than by steel.

There are various methods of giving the magnetic property to steel or iron, but for all these a magnet is necessary. In some cases, however, it appears to be acquired without the use of another magnet; but this is founded on a mistake.

If you take a bar of iron three or four feet long, and hold it in a vertical position, you will find that the bar is magnetic, and will act upon another magnet; the lower extremity of the bar attracting the south pole, and repelling the north pole. If you invert the bar, the polarity will be instantly reversed; the extremity which is now lowest, will be found to be a north pole, and the other extremity will be a south pole.

This is easily explained, when it is considered that the earth is itself a great magnet, and that the bar is placed by holding it nearly vertical, in the magnetical line, viz. in the direction of the dipping needle.

A bar of hard iron, or steel, will not answer for the above experiment, the magnetism of the earth not being sufficient to magnetise it.

Bars of iron that have stood in a perpendicular position, are generally found to be magnetical, as fire irons, bars of windows, &c.

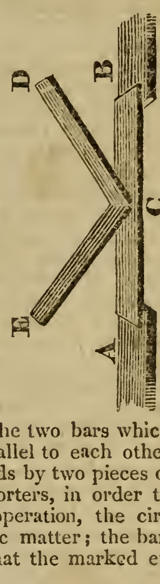
If a long piece of hard iron be made red hot, and then left to cool in the direction of the magnetical line, it becomes magnetical.

Striking an iron bar with a hammer, or rubbing it with a file, while held in this direction, likewise renders it magnetical. An electric shock produces the same effect; and lightning often renders iron magnetic.

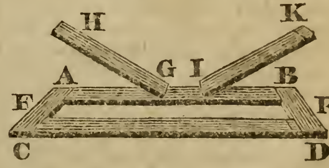
A magnet cannot communicate a degree of magnetism stronger than that which itself possesses, but two or more magnets, joined together, may communicate a greater power to a piece of steel, than either of them possesses singly: hence we have a method of constructing very powerful magnets, by first constructing several weak magnets, and then joining them together, to form a compound magnet, and to act more powerfully upon a piece of steel.

To give a detail of the various processes which have been suggested for the touching, or communicating the properties of the magnet to iron or steel, would alone fill a volume; we shall therefore only give an account of two general and good methods, which will be found adequate to every common purpose.

1. Place two magnetic bars, A B fig. 1, in a line with the north, or marked end of one, opposed to the south, or unmarked end of the other, but at such a distance from each other, that the magnet to be touched, may rest with its marked end on the unmarked end of A, and its unmarked end on the marked end of B; then apply the north end of the magnet D, and the south end of E to the middle of the bar C, the opposite ends being elevated as in the figure; draw D and E asunder along the bar C, one towards A, the other towards B, preserving the same elevation; remove D and C a foot or two from the bar when they are off the ends, then bring the north and south poles of these magnets together, and apply them again to the middle of the bar C as before; repeat the same process five or six times, then turn the bar, and touch the opposite surface in the same manner, and afterwards the two remaining surfaces; by this means the bar will acquire a strong fixed magnetism.

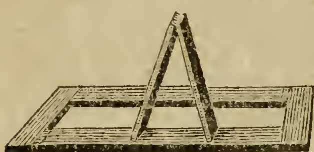


2. Place the two bars which are to be touched parallel to each other, and then unite the ends by two pieces of soft iron, called supporters, in order to preserve, during the operation, the circulation of the magnetic matter; the bars are to be placed so that the marked end D fig. 2,



may be opposite the unmarked end B; then place the two attracting poles G and I on the middle of one of the bars to be touched, raising the ends, so that the bars may form an obtuse angle of 100 or 120 degrees; the ends G and I of the bars

are to be separated two or three tenths of an inch from each other Keeping the bars in this position, move them slowly over the bar A B, from one end to the other, going from end to end about fifteen times. Having done this, change the poles of the bars (*i e.* the marked end of one is always to be against the unmarked end of the other), and repeat the same operation on the bar C D, and then on the opposite faces of the bars. The touch thus communicated may be further increased, by rubbing the different faces of the bars with sets of magnetic bars, disposed as in fig. 3.



In these operations all the pieces should be well polished, the sides and ends made quite flat, and the angles quite square.

A magnet, bent so that the two ends almost meet, is called a horse-shoe magnet. To render it magnetic, place a pair of magnetic bars against the ends of the horse-shoe, with the south end of the bar against that of the horse-shoe which is intended to be the north, and the north end of the bar to that which is to be south: the contact, or lifter of soft iron to be placed at the other end of the bars. Also rub the surfaces of the horse-shoe with a pair of bars placed in the form of a compass, or with another horse-shoe magnet, turning the pole properly to the poles of the horse-shoe magnet; being careful that these bars never touch the ends of the straight bars. If the bars are separated suddenly from the horse-shoe magnet, its force will be considerably diminished: to prevent this, slip on the lifter, or support, to the end of the horse-shoe magnet, but in such a manner, however, that it may not touch the bars; the bars may then be taken away, and the support slid to its place.

Magnetism is best communicated to compass-needles by the two following methods:

Procure a pair of magnetic bars, not less than six inches in length. Fasten the needle down on a board, and with a magnet in each hand, draw them from the centre upon the needle outwards; then raise the bars to a considerable distance from the needle, and bring them perpendicularly down upon the centre, and draw them over again. This operation repeated about twenty times will magnetize the needle, and its ends will point to the poles contrary to those that touched them.

2 Over one end of a combined horse-shoe magnet, of at least two in number, and six inches in length, draw from its centre that half of the needle which is to have the contrary pole to the end of the magnet; raise the needle to a considerable distance, and draw it over the magnet again; this repeated about twenty times at least, and the same for the other half, will sufficiently communicate the power. In communicating magnetism, it is best to use weak magnets first, and those that are stronger afterwards; but you must be very careful not to use weak after strong magnets.

A magnet loses nothing of its own power by communicating to other substances, but is rather improved thereby.

Every kind of violent percussion weakens the power of a magnet. A strong magnet has been entirely deprived of its virtue, by receiving several smart strokes of a hammer; indeed, whatever deranges or disturbs the internal pores of a magnet, will injure its magnetic force.

Fill a small dry glass tube with iron filings, press them in rather close, and then touch the tube as if it were a steel bar, and the tube will attract a light needle; shake the tube, so that the situation of the filings may be disturbed, and the magnetic virtue will vanish.

As both magnetic poles together attract a much greater power than a single one, and as the two poles of a magnet are generally in opposite parts of its surface, in which situation it is almost impossible to adapt the same piece of iron to both at the same time: two soft pieces of iron are applied to the poles of a loadstone, so as to project on one side of the magnet; these pieces being rendered magnetic, another piece of iron can be conveniently adapted to these projections, so as to let both poles act at the same time: The magnet in this case, is said to be *armed:* the pieces of iron are called the *armature;* the piece of iron that connects the poles, is termed the *lifter*.

To avoid the expence and trouble of the armature, artificial magnets have been made in the shape of a horse-shoe.

Magnets should never be left with two north, or two south poles together; for, when they are thus placed, they diminish and destroy each other's power. Magnetic bars should therefore be always left with the opposite poles laid against each other, or by connecting their opposite poles by a bar of iron. The power of a

magnet is increased by letting a piece of iron remain attached to one or both of its poles. A single magnet should therefore be always thus left.

The difference of steel in receiving magnetism is very great, as is easily proved by touching in the same manner and with the same bars, two pieces of steel of equal size, but of different kinds. With some sorts of steel, a few strokes are sufficient to impart to them all the power they are capable of receiving; other sorts require a longer operation; sometimes it is impossible to give them more than a small degree of magnetism.

A piece of spring-tempered steel will not retain as much magnetism as hard steel; soft steel still less, and iron retains scarce any. Iron when oxydated, loses its magnetism, and cannot be made magnetical; but when revived, it again acquires the magnetic virtue

The *mariner's compass*, or compass generally used on board of ships, consists of three parts; the box, the card or fly, and the needle. The box, which contains the card with the needle, is made of a circular form, and either of wood, brass or copper. It is suspended within a square wooden box, by means of two concentric circles called *gimbalds*, so fixed by cross axles to the two boxes, that the inner one, or compass-box, shall retain a horizontal position in all motions of the ship, whilst the outer, or square box, is fixed with respect to the ship. The compass-box is covered with a pane of glass, in order that the motion of the card may not be disturbed by the wind. What is called the card, is a circular piece of paper, which is fastened upon the needle, and moves with it Sometimes there is a slender rim of brass, which is fastened to the extremities of the needle, and serves to keep the card stretched. The outer edge of this card is divided into 360 equal parts or degrees, and within the circle of those divisions it is again divided into 32 equal parts or arcs, which are called the *points of the compass*, or *rhumbs*, each of which is often subdivided into quarters. The initial letters N, N, E, &c. are annexed to those rhumbs, to denote the north, north-east, &c. The middlemost part of the card is generally painted with a sort of a star, whose rays terminate in the above-mentioned divisions.

The magnetic needle is a slender bar of hardened steel, having a pretty large hole in the middle, to which a conical piece of agate is adapted, by means of a brass plate into which the agate case is fastened. The apex of this hollow cap rests upon the point of a pin which is fixed in the centre of the box, and upon which the needle, being properly balanced, turns very nimbly. For common purposes, those needles have a conical perforation made in the steel itself, or in a piece of brass which is fastened in the middle of the needle.

It must be observed, that the needle, which is balanced before it is magnetized, will lose its balance by being magnetized, on account of the dipping; therefore, a small weight, or moveable piece of brass, is placed on one side of the needle, by the shifting of which, either nearer to, or farther from the centre, the needle will always be balanced.

The *azimuth compass*, is nothing more than the above-mentioned compass, to which two sights are adapted, through which the sun is to be seen, in order to find its azimuth, and from thence to ascertain the declination of the magnetic needle at the place of observation: in one of these is an oblong aperture, with a perpendicular thread or wire, stretched through its middle, and in the other sight there is a narrow perpendicular slit. The ring of the gimbalds rests with its pivots on a semi-circle, the foot of which turns in a socket, so that whilst the box is kept steady, the compass may be turned round, in order to place the sights in the direction of the sun.

There are on the inside of the box two lines drawn perpendicularly along the sides; these lines serve to shew how many degrees the north or south pole of the needle is distant from the azimuth of the sun.

The *dipping-needle*, though of late much improved, is still, however, far from perfect. The general mode of constructing it is to pass an axis quite through the needle, to let the extremities of the axis, like those of the beam of a balance, rest upon its supports, so that the needle may move itself vertically round, and when situated in the magnetic meridian, it may place itself in the magnetic line. When it is used at sea, it is suspended by a ring. When it is placed upon a stand, a spirit-level is attached to it.

The greatest imperfection in this instrument is in the balancing of the needle, and the difficulty of ascertaining whether the needle retains its equipoise. In observing the dip of the needle at any particular place, the best method to avoid the error arising from the want of balance, is, 1st, to observe the dip of the needle, then to reverse its magnetism, by the magnetic bars, so that the end of the needle, which before was elevated above the horizon, may now be below it; and, lastly, to ob-

serve its dip again; for a mean of the two observations will be pretty near the truth, though the needle may not be perfectly balanced.

Theory of Magnetism.—It was mentioned before, that the earth may be considered as a great magnet. This is so clearly evident from a great variety of facts and observations, that there can be no doubt about it.

The directive property and dipping of the needle upon the surface of the earth, is exactly analogous to that of a small magnet upon the surface of a small globe, having a magnet inclosed within it, which apparatus is called a *terrella*.

The magnetism which iron acquires by its position, is another striking indication of the earth's magnetism. The immense masses of iron in various states, which exist every where in the globe, and which are often magnetic, prove that the earth is an immense magnet, and that its magnetism arises from the magnetism of all the ferruginous bodies contained in it.

The cause, however, of magnetic attraction and repulsion, is utterly unknown to us, nor has any thing farther than mere hypothesis been advanced to account for this, as well as every species of attraction. The most ingenious theory is that of Aepinus.

He supposes that there exists a peculiar fluid, which he calls the *magnetic fluid*, which is so subtile as to penetrate all bodies; and that it is of an elastic nature, viz. that its particles are repulsive of each other; also, that there is a mutual attraction between this fluid and iron, but that no other substance has any action upon it.

A ferruginous body, according to this hypothesis, is rendered magnetic by having the equable diffusion of the magnetic fluid disturbed throughout its substance, so as to have an overplus of it in one or more parts, and a deficiency of it in one or other parts; and it remains magnetic as long as its impermeability prevents the restoration of the equal diffusion of fluid, or of the balance between the overcharged and undercharged parts. Also the piece of iron is rendered magnetic, by the action of a magnet; because, when the overcharged part, or pole of the magnet, is presented to it, the overplus of magnetic fluid in that pole repels the magnetic fluid away from the nearest extremity of the iron (which therefore becomes undercharged), to a remote part of the iron, which becomes overcharged. If the iron be magnetized by the contact of the overcharged side of the magnet, then the matter of the latter attracts the magnetic fluid of the iron, to that extremity of the iron which lies nearest to itself.

Lay a sheet of paper flat upon a table, strew some iron filings upon the paper, place a small magnet among them, then give a few gentle knocks to the table, so as to shake the filings, and you will find that they dispose themselves about the magnet, the particles of iron clinging together, and forming themselves into lines, which, at the very poles, are in the same direction with the axis of the magnet: a little sideway of the poles they begin to bend, and then they form complete arches, reaching from some point in the northern half of the magnet to some other point in the southern half. The reason of this is, that each of the particles of iron is actually become magnetic, and possessed of the two poles; in consequence of which each particle, at the place where it happens to stand, disposes itself in the same manner as any other magnet would do; and, moreover, attracts, with its extremities, the contrary poles of other particles.

Take a strong magnet, and find out, by trial, such a piece of iron as is very little heavier than what the magnet will support. It is plain, that if you affix this iron to one pole of the magnet, the moment you remove your hand the iron will drop off.

But if, before you remove your hand, you present another larger piece of iron to the under part of the former, and at about half an inch from it, you will then find that the magnet will support the first piece of iron which it could not support before, when the secondary piece of iron was not below it. In short, a magnet can lift a greater weight of iron from over another piece of iron, such as an anvil, or the like, than from a table; the reason of which is, that, in the former case, the iron basis, or inferior piece of iron, becoming itself in some measure magnetic, helps to increase the magnetism of the first piece of iron, and consequently tends to increase the attraction.

Summary of the principal facts relative to Magnetism.

1. The cause of magnetism is totally unknown; some have attributed it to a peculiar fluid, which they have called the magnetic fluid.

2 Iron is the only known body that is capable of being possessed of magnetism.

3. Every magnet has two opposite points, which are called *poles*.

4. When a magnet is left at liberty to move freely, it places itself so that these

poles point nearly north and south. This is called the *directive property*, or *polarity* of the magnet.

5. When two magnets approach each other, their poles of the *same names*, that is, both their north poles, or both their south poles, *repel* each other.

6. But poles of *different* names *attract* each other.

7. The earth itself appears to be a great magnet, having its poles near to, but not coinciding with the ends of the imaginary axis, on which it turns.

8. Its poles act upon every small magnet attracting its contrary pole.

9. From this theory the *dip*, or *inclination* of a magnet to the plane of the horizon is easily explained.

10. The deviation of the direction of a magnet from due north and south, is owing to the situation of the magnetic poles of the earth, and is called the *declination* of the magnet.

11. The magnetic poles of the earth are not stationary, but are continually changing their places.

12. This occasions a constant change of the declination, and this is called the *variation of the compass*.

13. The loadstone is an iron ore naturally possessing magnetism.

14. Magnetism may be communicated to iron and steel.

15. Pure iron most easily receives magnetism, but loses it immediately.

16. Iron combined with carbon, as hard iron or steel retains the magnetic properties when communicated to it.

17. A steel bar rendered magnetic, and fitted up in a box, so as to move freely in every direction, constitutes the *mariner's compass*.

MAHOGANY. The swietenia mahagoni, or Mahogany tree, is a native of the warmest parts of America, and grows in the island of Cuba, Hispaniola, and the Bahama islands. It abounded formerly in the low lands of Jamaica, but it is now found only on high hills, and places difficult of access.

This tree grows tall and straight, rising often sixty feet from the spur to the limbs; and is usually four feet in diameter. The foliage is a beautiful deep geeen, and the appearance made by the whole tree so elegant, that none could be more ornamental for an avenue. The flowers are of a reddish or saffron colour; and the fruit of an oval form, about the size of a turkey's egg. Some of them have reached to a monstrous size, exceeding one hundred feet in height. One was cut about thirty years since in St. Elizabeth's in Jamaica, which measured twelve feet in diameter, and cleared to the proprietor 500*l.* currency. In felling these trees the most beautiful part is commonly left behind. The negro workmen raise a scaffolding of four or five feet elevation from the ground, and hack up the trunk, which they cut up into balks. The part below extending to the root is not only of larger diameter, but of a closer texture than the other parts, most elegantly diversified with shades or clouds, or dotted like ermine, with black spots; it takes the highest polish, with a singular lustre. This part is only to be come at by digging below the spur, to the depth of two or three feet, and cutting it through; which is so laborious an operation that few attempt it, except they are uncommonly curious in the choice of their wood, or to serve a particular order.

The mahogany tree thrives in most soils, but varies in texture and grain, according to the nature of the soil. On rocks it is of a smaller size, but very hard and weighty, and of a close grain, and beautifully shaded; while the produce of the low and richer lands, is observed to be more light and porous, of a paler colour and open grain; and that of mixed soils to hold a medium between both. This constitutes the difference between the Jamaica wood and that which is collected from the coast of Cuba and the Spanish Main, the former is mostly found on rocky eminences, the latter is cut in swampy soils near the sea coast. The superior value of the Jamaica wood, for beauty of colouring, firmness, and durability, may therefore be easily accounted for; but as a large quantity of balks and planks is brought from the Spanish American coasts to Jamaica, to be shipped from thence to the United States, the dealers are apt to confound all under the name of Jamaica wood, which in some measure hurts the credit of this staple production.

This wood is generally hard, takes a fine polish, and is found to answer better than any other sort, in all kinds of cabinet ware. It is a very strong timber, and was frequently used as such in Jamaica, in former times. It is said to be used sometimes in ship building; a purpose for which it would be remarkably adapted if not too costly: being very durable, capable of resisting gun shots, and burying the shots without splintering.

It was not till the commencement of the last century that mahogany was imported with the view of making household furniture of it. The carpenters in the beginning found this wood much too hard for their tools, and it was some time before this difficulty was overcome. The prac-

tice of *veneering* is much used in this country.

MAIZE, Indian corn. See AGRICULTURE.

MALT, is barley prepared for brewing into beer, ale, and porter. See BREWING.

MALTING, an operation of making malt. See BREWING.

Besides the remarks we have made on malt, it may be proper to add, that, in order to determine the quality of malt, a handful of it should be thrown into cold water, where those grains that are imperfectly germinated, will swim with one end upwards (Dr. Darwin supposes with the root end); and such as are properly malted, float on their side; whereas sound, ungerminated barley, uniformly sinks in water. Another criterion of good malt is, its agreeable saccharine taste; and, when the whole contents of the grain easily crumble into powder, and dissolve in the mouth. In short, it ought to be pure, dry, and to emit a strong, agreeable odour.

Malt-dust, or the refuse that falls from malt in drying, affords an advantageous manure for wheat land, especially if it be scattered as a top-dressing. The proper quantity of this dust is 80 bushels per acre for wheat, and about 60 bushels for barley: it is also eminently calculated for grass-lands; and, if applied in the latter proportion, it will produce a very considerable increase of the best seed. Such manure, however, is most beneficial to clay soils, or stiff loams; as, on gravelly land, and in dry seasons, it will be apt to burn the soil. But, if the succeeding weather be moist, it will be productive of great benefit; for the first shower washes it into the earth, and thus secures the crop, which not only becomes finer and more abundant, but the soil is at the same time effectually cleared from the noxious weeds, that frequently vegetate, when common dung is employed.

As malt forms so essential an article of domestic consumption, and is not at all times within the reach of the poor, various recipes have been given for making beer with a small portion of, or wholly without malt. We add the following method of brewing beer, as tending to diminish the consumption of, and thus in some measure to serve as a substitute for, that valuable grain. It consists simply in adding 28lbs. of dry, well-tasted brown sugar, to half a load, or three Winchester bushels of malt. The latter is to be brewed in the usual manner with hops, after which the sugar is to be introduced, and the liquor stirred till the whole is dissolved. Thus, a wholesome beverage may be procured at about three-fourths of the expence usually incurred by using malt and hops only; because a smaller proportion of the latter plant now answers the purpose.

Among the different patents that have been granted for inventions, or improvements, relative to the preparation of beer, the following claim more particular notice; namely, Mr. Dearman's for his contrivance of mills for grinding malt, in 1779; Mr. Jones's in 1798, for a machine, calculated to mix malt, or other substances, more intimately with fluids; and Mr. Tickle's, in 1801, for more effectually dissolving and extracting the virtues of malt, hops, and other vegetable substances. As our limits will not permit us to detail these pretensions to ingenuity, we refer the reader to the later volumes of the *Repertory of Arts and Manufactures*. In the 15th volume of the same work, we meet with a communication from Mr. Joseph Coppinger, containing a description and plan of a malt and corn-kiln of his invention. He observes, that it is particularly adapted to the use of farmers, who frequently lose considerable quantities of grain during damp or wet seasons, for want of a similar contrivance. Its advantages are stated to be: 1. That it may be erected either in a loft or on the ground-floor, and at one-tenth part of the expence. 2. Any kind of fuel may be employed without detriment to the malt or corn dried in it. 3. The heat will be more uniformly distributed, without any waste, as is the case with most of the common kilns. Lastly, the health of the attendants, necessarily employed, will not be exposed to certain injury, in consequence of their breathing, or sleeping in an unwholesome atmosphere; as their beds will be placed in a shed on the outside of the building. This circumstance, being of the greatest importance, deserves serious attention; and we trust that the contrivance here suggested, will be generally adopted.

MALT SPIRITS, are liquors made from malt, in which distillation is used, and comprehends all those fluids in which malt is used in their preparation. See SPIRIT, ALCOHOL, &c.

MALVOISIE, to imitate. Take of the best galangal, cloves and ginger, each one drachm; bruise them coarsely, and infuse for twenty-four hours, with brandy, in a well closed vessel; then take these drugs out, and having tied them in a linen bag, let them hang in the cask by the bung-hole. Three or four days after, your wine will taste as good and as strong as natural Malvoisie. IMISON.

MALTHEA. See BITUMEN.

MANGE. See FARRIERY; also ANIMALS, domestic.

MANGANESE. Manganese is a metal of an iron-grey colour, brittle, and easily oxydable on exposure to the air. When in the state of black oxyd it communicates to borax a red tinge, which is destroyed by the internal blue flame of the blow-pipe, but is restored by the external flame or the addition of nitre.

Ores of Manganese.

Sp. 1. Grey Manganese.

Of this there are reckoned the four following subspecies.

1. *Subsp.* Radiated grey manganese.
2. *Subsp.* Foliated grey manganese.
3. *Subsp* Compact grey manganese.
4. *Subsp* Earthy grey manganese.

Sp. 2. Black manganese.

Sp. 3. White manganese.

Sp. 4. Red manganese.

Sp. 5. Sulphuret of manganese.

Sp. 6. Phosphat of manganese and iron.

Reduction of Ores.

As manganese is applied to no use in its metallic state, there are no establishments for the reduction of its ores in the great way; and even in the laboratory the process is seldom performed, chiefly on account of the intense heat which is requisite, and which cannot be obtained in small furnaces unless they are peculiarly well constructed. The use of all alkaline and vitreous fluxes must be carefully avoided; for the affinity of these with the oxyd of manganese is so considerable as entirely to prevent its reduction where they are present. The only method which has been attended with any tolerable success is the following, invented by Bergman. Select a sound and very refractory crucible and line it with charcoal, or still better with a mixture of linseed meal and water, beaten up with as much finely sifted charcoal as it will take without losing its tenacity; dry the crucible thoroughly, gradually increasing the heat till the meal begins to be scorched; then take some oxyd of manganese (purified from all extraneous substances as described in the last section) and make it up into a ball with any kind of oil; put this into the cavity of the crucible and cover it with powdered charcoal; then lute on a pierced cover or an inverted crucible, and place it in a blast furnace; keep it at a moderate red heat till the jet of blue flame through the hole in the cover has ceased, then bring the furnace rapidly to its highest heat, and keep it so for forty minutes or three quarters of an hour: after this let the fire go out, and when the crucible is quite cold, break it up carefully and the manganese will be found in globules of various sizes covered for the most part with a thin vitreous crust. It appears probable that a button might be obtained by a second fusion of these globules with glass of borax, in a crucible lined with charcoal and a little pipe-clay to prevent the flux from sinking through the pores of the charcoal.

Some of the physical and chemical properties of manganese

The colour of manganese is greyish-white with a considerable metallic brilliancy. Its fracture is uneven granular: its hardness is somewhat greater than that of cast iron; and it is very brittle. Its sp. gr. according to Bergman, is 6.85, according to Hielm is 7. In fusibility it appears to rank between platina and iron: when pulverized it is feebly attracted by the magnet, but this is probably owing to the presence of iron, from which it is seldom absolutely free.

No other metal is so easily oxydable as this. If a globule of manganese be broken and exposed to the air, the fractured surface almost immediately loses its metallic lustre and acquires a greyish tarnish; in a few seconds more it becomes lilac coloured, then violet, and lastly brownish-black; when in this state, it is friable and breaks down between the fingers into a black powder, resembling in appearance the native grey oxyd. It is by no means however as yet at a high degree of oxydation, for when treated with dilute sulphuric acid it gives out hydrogen gas; after a few days however of exposure to the atmosphere it becomes more saturated with oxygen and then loses this property. When heated below ignition in contact with atmospheric air, nearly the same effect takes place as at the common temperature, only more rapidly.

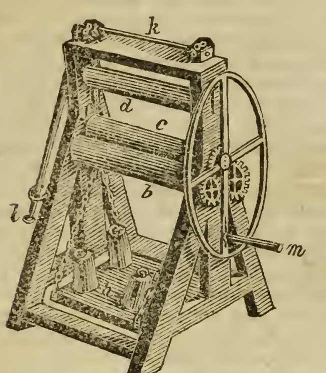
Chemists at present distinguish three degrees of oxydation of this metal, each of which is characterized by a remarkable change of colour. The white oxyd contains the smallest proportion of oxygen, and the black oxyd the largest; the red oxyd holds an indeterminate place between the two others.

The only use of manganese is in the state of black oxyd. It is employed in the laboratory as the cheapest and most convenient material from which to procure oxygen gas. All the oxymuriatic acid consumed in the bleacheries in Europe is prepared from manganese and the usual materials of muriatic acid. Finally it is largely employed by the glass-makers, both as a colouring material and for the purpose of destroying the colour of the

finer kinds of glasses ; hence its common appellation of glass soap. It may be remarked by the bye that this latter application of manganese to the purposes of art is by far the most ancient, it being distinctly mentioned by Pliny in his Natural History, whereas the others do not date further back than the commencement of pneumatic chemistry. Manganese has been discovered in the United States.

MANGLE, a machine for smoothing linen which cannot be ironed. There are various forms of mangles. Without describing them, we shall here introduce an improved one, for an account of which we are indebted to Dr. Mease.

The celebrated mangle of Mr. Jee was found on trial in this city to be defective, or not to work as well as described, and required withal great power. Mr. Morris, of London, has lately obtained a patent for one, of which the following is a description. Dr. Mease informs us, that this mangle is now in general use in England.



Description.—Two horizontal cylindrical rollers form a bed for the roller on which the linen to be mangled is rolled. One of them, *b*, is seen in the drawing. The axis of those rollers bear on brass, let into the wood frame, and have a wheel fixed to each, which works in a pinion on the axis of the fly wheel, as seen in the drawing: *c*, a moveable roller on which the linen to be mangled is rolled: *d*, a roller, the axis of which works in pieces of brass which slide between iron, let into the inner side of the wood frame, to the bottom of which, long pieces of iron, *f*, are fixed with hooks at their lower extremities, to which are attached the chains that support the scale or platform, *h*, where iron weights, or any other heavy substance, are placed ; to the top of the brass in which the roller *d* works, the engine chains are fastened, which pass through apertures at each end of the top of the wood frame, and are there again fastened on the pulleys of the shaft *k* with a screw : *l* is a lever fixed to the end of the shaft *k*.

To use the machine, press the lever *l*, and fasten it with the hook, which raises the roller *d* with the platform and weights attached to it ; then take out the roller *c*, and roll the linen and mangling cloth round it, and replace it on the two bottom rollers, unhook the lever *l*, and the weights on the platform will press the roller *d* on the roller *c* ; give motion to the fly wheel, and also to all the rollers, by turning the handle *m*, which in a short time will make the linen beautifully smooth ; press down the lever, fasten it with the hook, and take the roller *c* out : a spare roller is supplied, so that if two people are employed, one may be filling it with linen, while the other is mangling.

None of the recent improvements in machinery have excited so much general attention as this machine; being constructed on true mechanical principles, and worked by one person with the greatest ease. From experiments which have been tried with it, it is found it will pass over all inequalities without the least difficulty or obstruction, the top cylinders and weights rising and falling as they approach; from the two bottom cylinders being put a little asunder, the one on which the linen is rolled acts as a wedge, greatly increasing the power of the weights, giving the linen three equal pressures. Upon the whole, this machine mangles with greater ease, performs its work better, and with more expedition, than any machine before invented ; is very compact in its construction, and never subject to be out of repair.

MANUFACTURE of Alum. See Alum.

Manufacture of Annatto. See Annatto.

Manufacture of Aqua Fortis. See Nitric Acid.

Manufacture of Barilla. See Soda and Barilla.

Manufacture of Baskets.—Baskets are made of willows, which, according to their manner of growth, are called osiers and sallows. They thrive best in moist places ; and the proprietors of such marsh lands in Europe, generally let what they call the willow-beds to persons who cut them at certain seasons, and prepare them for basket-makers. To form an osier-bed, the land should be divided into plots six, eight, or ten feet broad, by narrow ditches ; and if there is a power of keeping water in these cuts at pleasure, by means of a sluice, it is highly advantageous in many seasons. Osiers planted in small spots,

and along hedges, will supply a farmer with hurdle-stuff, as well as with a profusion of all sorts of baskets. The common osier is cut at three years, but that with yellow bark is permitted to remain a year longer.

When the osiers are cut down, those that are intended for white work, such as baskets used in washing, are to be stripped of their bark, or rinds, while green. This is done by means of a sharp instrument, fixed into a firm block: the osiers are passed over this, and stripped of their covering with great velocity. They are then dried, and put in bundles for sale. Before they are worked up, they must be previously soaked in water, which gives them flexibility.

Hampers and other coarse work are made of osiers, without any preparation except soaking. Some expert workmen make a variety of articles of wicker manufacture, as work-baskets of different descriptions. The ancient Britons were celebrated for their ingenuity in manufacturing baskets of very elegant workmanship, which they exported in large quantities.

The American Indians, in particular, are very expert and ingenious in this art: besides forming baskets of different shapes and fashions, they colour or dye the substance of which they are made of different colours, principally obtained from indigenous plants. See Bartram's Travels among the Indians.

Manufacture of Beer and Ale. See Brewing.

Manufacture of Brass. See brass, copper, zinc.

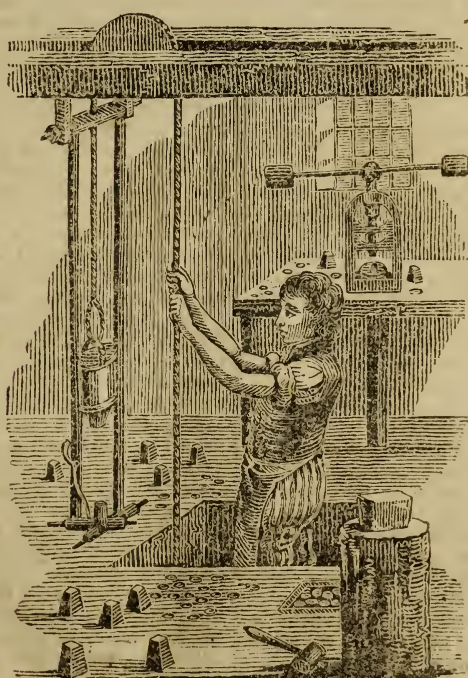
Manufacture of Bread. See Bread.

Manufacture of Brimstone. See Sulphur.

Manufacture of Butter. See Butter.

Manufacture of Buttons. There are several kinds of buttons; some made of gold and silver lace, others of mohair, silk, &c. and others of metal. The figure represents a man who makes or stamps metal buttons only. The process is very simple, after the metal comes out of the founder's hands.

The pieces of metal are either cast or cut to the proper size, and then sent to the button-maker, who has dies or stamps



according to the pattern wanted. The machine by which they are stamped, is well exhibited in the figure. The man stands in a place lower than the floor, by which he is nearer on a level with the place on which his dies stand: by means of a single pulley he raises a weight, to the lower part of which is fixed another die; he lets the weight fall down on the metal, and the thing is done. After this operation they are to be shanked; which is performed by means of solder: they are then polished by women. At Birmingham, (Eng.) this manufacture is carried on upon a very large scale. The late John Taylor, esq. was the inventor of gilt buttons; and in his house, buttons have been manufactured to the amount of 800*l.* per week. This manufacture will be presently noticed.

Besides those cast in a mould, there are great quantities of buttons made of thin plates. The plates are brought to a proper degree of thickness by the rolling-mill: they are then cut into round pieces of the size wanted. Each piece of metal thus cut, is reduced to the form of a button by beating it in several spherical cavities, beginning with the flattest cavity, and proceeding to the more spherical, till the plate has got all the *relievo* required; and, the more readily to manage so thin a plate, ten or a dozen of them are formed to the cavities at once. As soon as the inside is formed, an impression is given to the outside, by working it with an iron puncheon, in a kind of mould like minters' coins, engraven indentedly, and fastened to a block or bench. The cavity of the mould in which the impression is to be made, is of a diameter and depth suitable to the sort of button to be struck in it; each kind requiring a particular mould.

The plate, thus prepared, makes the upper part or shell of the button. The lower part is formed of another plate, made after the same manner, but flatter, and without any impression. To this is soldered a little eye, made of wire, for the button to be fastened by.

The two plates are soldered together with a wooden mould, covered with wax or rosin between, to render the button solid and firm; for the wax or other cement entering all the cavities formed by the *relievo* of the other side, sustains it, prevents its flattening, and preserves its design.

Buttons may be made of tin, in imitation of worked buttons of gold and silk in the following manner:

Take lamp-black; grind it with oil of spike, and mark the ground-work with a pencil; when dry, draw it all over with varnish: the best way to imitate worked buttons is, to do them in a fine mould, either stamped or cast; the ground is first filled up with black, blue, red, or any other colour; then the raised part is to be wiped very clean, and when dry, to be drawn over with the varnish, which will make it look much finer than what can be done upon a plain button.

For a brown colour take umber.

For green take distilled verdigrise, mixed with other colours, to make it either deeper or lighter.

For grey take white lead, and lamp-black.

All your colours must be ground with oil of spike.

In this manner you may embellish pewter, with a coat of arms, cypher, or ornaments; that is, such pewter things as are not to be scowered.

The following is a brief account of Gilt Buttons, comprising some improvements, important to manufacturers. Communicated by Messrs. Collard and Frazer, of Birmingham, to A. Tilloch.

As the means employed in the manufacture of plain gilt buttons are not universally known, the following summary, while it points out to the manufacturer many considerable advantages, in the use and recovery of his mercury, will also, it is hoped, be found interesting to many of our readers.

The copper, properly alloyed, is first taken to a rolling mill, and reduced between iron rollers to a proper thickness for the button. The sheets of copper are then brought to the button manufactory, and cut into circular pieces of the size of the intended button, by means of a fly-press. In this state they are called *blanks*, and resemble halfpence and farthings worn smooth by long circulation.

The shanks, which are made with wonderful facility and expedition by means of a very curious machine, are then secured to the bottom of each button by a small iron crank, and a small quantity of solder and rosin applied to each. Thus they are placed on a sheet of iron, containing about a gross, and introduced into a very hot stove, where they remain till the workman is satisfied that the solder has melted, and that the shanks are united to the button; after which the edges are smoothed in a lathe.

The next process is what they call *dipping;* that is, a quantity, consisting of a few dozens, is put into an earthen vessel full of small holes like a cullender, and thus dipped into diluted nitric acid to clean them from dirt and rust. They then, according to the best practice, go in-

to the hands of the burnisher, who, in a lathe, burnishes the tops, bottoms, and edges, with a hard black stone, got from Derbyshire, (Eng.) secured in a handle like the diamond of a glazier: this he applies to the button fixed in the end of a piece of wood, turned with great velocity by means of a treddle with which he works the lathe. This is called *rough burnishing*, and is a modern improvement: it is of great advantage, for it closes the pores of the metal opened by the acid, so that the gold afterwards to be applied, attaches to a smooth surface, which otherwise might enter into imperceptible cavities, and be closed up in the body of the button by the final burnishing. When the buttons come from the burnisher they are fit for gilding. This is a very curious operation, and truly chemical.

The first process towards gilding, is what they call *quicking*, which is effected as follows:—Any given quantity of buttons, perhaps a gross, is put into an earthen vessel, with a quantity of mercury, which has been previously saturated with nitric acid; and thus the buttons and mercury are stirred together with a brush till the mercury, carried by the affinity of the acid to the copper, adheres to the whole surface of the button. The buttons are then taken out, and put into what is called a *basket*, though in fact, an earthen vessel full of small holes, the handle of which the operator holds in his hand, and jerks it with considerable force down towards a wooden trough (a receptacle for the quicksilver) till, by repeated jerks, all the loose particles of mercury are disengaged, leaving a complete continuity over the surface, and giving them the appearance of silver buttons.

Now the gold, a grain of which will spread over many superficial feet of copper, is thus prepared: Any given quantity of mercury is poured into an iron ladle, the inside of which having been previously *guarded*,—that is, rubbed over with dry whiting to prevent the gold from adhering to the iron,—into this mercury is thrown the portion of pure gold intended to cover a given quantity of buttons. The gold and mercury are heated together in the iron ladle till the workman (whose practice soon enables him to judge) perceives that there is a perfect union between them; when he empties his ladle into a vessel containing cold water.

The amalgam being cold, is put into a piece of shamoy leather, and squeezed till no more mercury will pass through. What passes the shamoy contains not the smallest portion of gold; what remains will be about the consistency of butter, so completely united, that every particle of mercury shall contain an equal portion of gold. The amalgam should be then put into an earthen vessel, and a small quantity of nitric acid added thereto, allowing sufficient time for the acid to unite with the mercury. But the buttons and amalgam are commonly introduced first, and a quantity of diluted nitric acid added thereto, so that, for want of a complete union between the mercury and acid first, if there be not a superabundancy of acid, there may not be sufficient to carry all the amalgam to the surface of the buttons.

When the acid has had sufficient time to *embrace* (as workmen call it) the mercury, the buttons should be introduced, and be stirred till the amalgam, carried by the affinity of the acid to the copper, and the tendency which the gold has to extend itself to the mercury with which the buttons have been previously quicked, completely attaches to the whole surface.

It is the next process in which we principally wish to recommend a deviation from the old practice, by which most of the mercury will be recovered, and the gilder's health, in a great measure, preserved from the dreadful effects of volatilised mercury.

The old practice is as follows: The buttons being completely covered with mercury and gold, the operator proceeds to that business which is called *drying off*, which is performed thus: The buttons, to the quantity of a few dozens, are put into an iron pan somewhat like a large frying-pan, placed over a fire, and gently shook, while the operator watches carefully till he observes the mercury begins to flow; upon the first symptom of which, he takes the pan from the fire, and throws the buttons into a large cap, called a *gilding cap*, like a man's hat with a very small brim, but much larger in the crown, made of coarse wool and goats hair. In this cap, with a circular brush, the buttons are stirred, to spread the gold and mercury while in a degree of temperature nearly sufficient to volatilise the mercury. The buttons are again thrown into the pan, placed over the fire, and shaken, while the mercury gently volatilises. The buttons are again thrown into the cap, and stirred with the brush. This process is continually repeated, till all the mercury is volatilised, leaving the gold on the buttons, which appear again of a yellow colour.

Thus a principal part of the mercury ascends the chimneys, is deposited on the tops of the houses and about the adjacent neighbourhood, and great quantities are

inhaled and absorbed by the operator, keeping him nearly in a state of salivation till disease obliges him to desist.

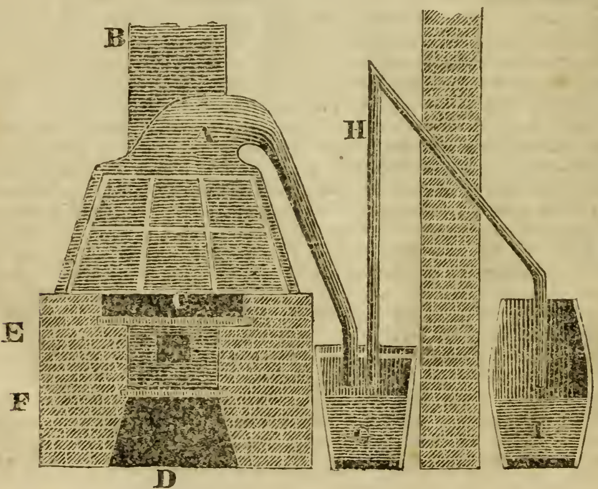
Considerable quantities of mercury thus volatilised are found united and collected in small pools in the spouts and gutters on the tops of the buildings. Thus many tons of mercury have been dissipated about the town of Birmingham, (Eng.) to the great injury of the inhabitants. The poor sweep who has ascended the chimneys has been salivated, and the manufacturer has sustained considerable loss

To preserve a principal part of the mercury thus dissipated, and to prevent, in a great measure, the terrible effects of it on the constitution of the operator, is the object of these remarks, as far as it regards manufacturers.

By means of an apparatus similar to the plan delineated in the figure, which has been partially and successfully adopted by Mr. Mark Sanders, an eminent button-maker of Birmingham, the principal part of the mercury may be recovered, and the health of the operator greatly preserved.

A hearth of the usual height is to be erected, in the middle of which a capacity for the fire is to be made; but instead of permitting the smoke to ascend into the top A, made of sheet or cast iron, through which the mercury is volatilised, a flue for that purpose should be conducted backwards to the chimney B An iron plate, thick enough to contain heat sufficient to volatilise the mercury, is to cover the fire-place at the top of the hearth C. There must be an ash-hole, D, under the fire-place. The square space E, seen in the fire-place, is the flue, which serves to carry the smoke back under the hearth into the chimney B. The door of the fire-place and ash-pit may either be in front, as represented in the figure, or at the end of the hearth at F, which will perhaps less incommode the work-people. It would be of great advantage if the space between A and the iron plate C was covered up with a glass window coming down so low as only to leave sufficient room for moving the pan backwards and forwards with facility. If the sides were also glass instead of brick-work it would be still better, as the work-people would be able to have a full view of their work without being exposed to the fumes of the mercury, when volatilised by heat communicated to the pan by the heated iron plate over the fire-place, would ascend into the top A, appropriated for its reception, and descend into the tub G, covered at top and filled pretty high with water. By this means the hearth would, in fact, become a distilling apparatus for condensing and recovering the volatilised mercury. In the tub G the principal part would be recovered; for, of what may still pass on, a part would be condensed in ascending the tube H, and fall back, while the remainder would be effectually caught in the tub or cask I, open at the top and partly filled with water. The latter tub should be on the outside of the building, and the descending branch of the tube H should go down into it at least 18 inches, but not into the water. The chimney or the ash-pit should be furnished with a damper, to regulate the heat of the fire.

The water may be occasionally drawn out of the tubs by a siphon, and the mer-



cury clogged with heterogeneous matter may be triturated in a piece of flannel till it passes through, or placed in a pan of sheet iron, like a dripping-pan, in a sufficient degree of heat, giving it a tolerable inclination, so that the mercury, as it gets warm, may run down and unite in the lower part of the pan. But the mercury will be most effectually recovered by exposing the residuum left in the flannel bag to distillation in a retort made of iron or of earthenware.

When the mercury is volatilised from the buttons, or, as the workmen denominate it, when the buttons are dried off, they are finally burnished, and are then finished and fit for carding.

The reader unacquainted with this branch of manufacture will be surprised to learn how far a small quantity of gold, incorporated with mercury, will spread over a smooth surface of copper. Five grains, worth one shilling and threepence, on the top of a gross, that is, 144 buttons, each of one inch diameter, are sufficient to excuse the manufacturer from the penalty inflicted by an act of the British parliament; yet many, upon an assay, are found to be deficient of this small quantity, and the maker fined, and the buttons forfeited accordingly. Many hundred grosses have been tolerably gilt with half that quantity; so extremely far can gold be spread, when incorporated with mercury, over the surface of a smooth piece of copper. See Gilding.

Manufacture of Cat-gut.—If the intestines of sheep and lambs be first cleansed, and then dried and twisted together, either singly or several together, cat-gut will be made. The manufacture of this article is exceedingly simple; the principal object is having a good gut, uniformity in the twisting, and caution in drying. Owing to the great consumption of this article by violin-makers, watch-makers, hatters, cutlers, turners, &c. it is always in demand. Some time since a considerable manufactory was established in this city. The turner instead of using cat-gut with the lathe, employ the hide of horses or cows, which they soak and cut into strings; after twisting which, they dry them. The firmness of these strings is owing to the gelatin contained in the skin.

Another use of cat-gut is for the construction of hygrometers: the gut will contract in dry weather, and extend as the air becomes moist, and the difference may be readily shown.

Manufacture of Calico. See Printing.

Manufacture of Camphor, refining. See Camphor.

Manufacture of Cheese. See Cheese.

Manufacture of Cloth.—Cloth, in commerce, in its general sense, includes all kinds of stuffs woven or manufactured on the loom, whether their threads be of wool, cotton, hemp, or flax.

The term cloth is, however, more particularly applied to the web or tissue of woollen threads interwoven, whereof some called the warp are extended lengthwise from one end of the piece to the other, the rest, called the woof, are disposed across the first, or breadthwise of the piece.

The manufacture of this important article naturally divides itself into several branches. The first and most important of which, seems to be a judicious choice of the wool, since no process can remedy a defect in that article. It is therefore of primary importance that the artist should make himself well acquainted with the different kinds of wool and their qualities.

When a manufacturer is about to purchase of this article, care should be taken to examine well the body; that is to say, the strength and fineness, and to see, by separating it with the hands, that it has a proper degree of softness, that it is not too greasy, and above all, that it does not consist of different qualities of wool mixed together.

The French name three modes which may be considered in a general way as the best by which to ascertain the quality of wool, namely, inspection, smell and sound.

By inspection a very little practice will enable us to determine its relative fineness, softness, and length of staple; and to see that it be clean and not scabby; and having acquired by such practice a better knowledge of the article, we shall soon be enabled to judge if it comes from the same flock of sheep without any mixture of the wool from an inferior one, or from lambs.

Among the Spanish wool imported into the French market, there are bales consisting of well shorn fleeces of fresh wool, free from all kinds of admixture or dirt. These are called Cavalieres, and are in the highest estimation. They also prefer wool which has a little of a reddish cast, and the more it swells when drawn from the bale or sack in which it has been compressed, the better is the quality. By the smell may be discovered the freshness of the article, if it be all new, or mixed with old wool. If it smell of the yoke, the odour will be fresh, and then it is considered new; but if it have a stale, greasy smell, it is then the wool of several years, mixed. Although it is said by some that

good wool may be preserved raw, many years experience has taught manufacturers that wool never works to so much advantage as when perfectly fresh.

The grease, or yoke, as it is called, is a kind of fat or oil adhering to the wool, which arises from the perspiration of the sheep, as well when pastured as when fed in the fold. When sheep are too much confined in this latter place, the yoke adheres too much to the wool, and injures its quality by the great waste which it occasions.

By our sense of hearing we may form a judgment whether the wool be new or old, for if we take a small handful and put it to the ear, rubbing it between the thumb and fore-fingers, and then draw it out, shaking it, at the same time, if it give a sharp sound, it is dry and light, and is certainly old; but if it give a soft sound it is the wool of the season. In this mode of judging, Mr. Rousseau cautions us to be careful to distinguish between the softness caused by the exposing the wool to the operation of steam, which produces an effect on old wool, to make it not easily distinguishable from the wool of the season.

The most perfect mode to ascertain the quality of wool by sample, is to subject it to the several operations of washing, beating, and picking; these different manipulations will shew what may be expected when the article shall be worked up, and are rendered necessary from the very great waste which attends the working of some wools, which, although they may be of a very good quality, will produce great loss to the manufacturer, whose interest will be found to consist in never attempting the manufacture of ordinary wool.

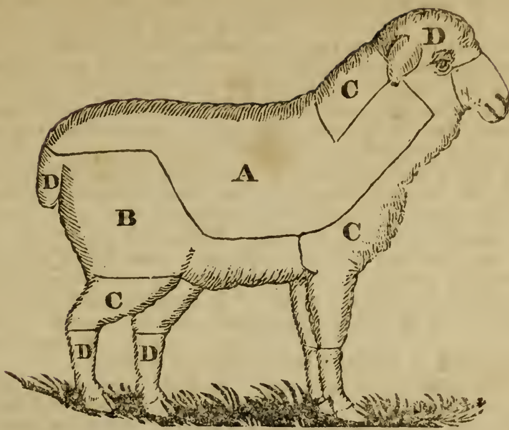
Of the Washing.—In Spain the wool of the merino sheep is scoured after it is shorn; and by skilful shepherds, the mode of washing the wool on the sheep's back is condemned, because dangerous to this animal, and really of trifling advantage to merino wool, the thick yoke of which can be but in a small degree discharged by ablution in cold water; nor is the trouble to the artist much, if any, less, as the wool will have to go through another thorough washing before it can be manufactured.

There is, we think, risk in a general way in the washing of wool on the back of the sheep, particularly if they be exposed to severe cold and rain. Many sheep have fallen a sacrifice to the cold of this climate, but this may be attributable perhaps with good cause to the improper privation of their warm clothing and consequent exposure at an inclement season of the year. From the twentieth of May to the latter end of June is considered the proper season for washing the merino sheep, having a regard always to the temperature of the weather, and choosing it as much as possible when pleasant and dry; with this precaution the washer should stand in a running stream of sufficient depth to be up to his waist, plunging the sheep repeatedly into the stream, and rubbing the wool well with the water; and when in his opinion the wool is as clean as it can be made by this process, the water should be well squeezed out of it, beginning with the head of the animal and proceeding to the extremities.

If this plan be pursued with due attention to the weather, it is presumed the risk is not great, yet we only give it as the mode most likely to accomplish the object of washing the wool on the back of the sheep without the usual bad consequences, not wishing to encourage the practice too much, or to forbid it altogether.

When the above plan has been adopted it will be necessary to see that the sheep are kept for a few days immediately there after in a clean pasture, that the wool may become dry, and that the yoke may rise again, which will render the fleece more soft and pliable. Mr. Bakewell recommends a plan adopted by some merino breeders in Sweden of placing the animal on his back with his head up in a large tub, washing him well with a mixture of warm water and a small quantity of stale urine or soap leys, and then to clean him well in pure water. Mr. B. says this plan will render Spanish wool seven per cent. cleaner than cold water, and with much less risk of felting it than if so washed after being shorn.

The following figure shews the mode of assorting wool in Spain, into four different qualities. When thus assorted they are packed for the market—A. No. 1, or Rafina; B. No. 2, or Fina; C. No. 3, or Tercera; D. No. 4, or Kahida.



If it be necessary to do this at all, the time of shearing appears certainly best adapted to it, but as we have never heard that any other nation have adopted it, we have given it here only as matter of information, leaving it to those more immediately interested to decide if it have any advantage over the common plan of assorting the wool by the manufacturer.

All mixture of wools of different grades or mixed flocks should be studiously avoided, as tending very much to lessen their respective value.

With these observations on the modes of preparing the wool we now proceed to give the best account we have been enabled to obtain of the manufacture of superfine cloth in Wiltshire, England.

It is previously to be observed, that all the cloths which are designed for scarlets, greens, and blacks, as well as many of the most lively and delicate colours, are manufactured white, and dyed in the piece after they are finished.

The wool, being taken out of the bale, must first be picked, to clear it from the pitch which adheres to it, and from the other extraneous substances with which it abounds. It must then be scoured, by putting it into a furnace containing a liquor composed of three parts of water and one of urine. After it has been well stirred about therein, and the grease it contains dissolved, it must be taken out, drained, and washed in running water, and in that state it is fit to be committed to the dye-furnace. See Dyeing.

After dyeing it must be again washed and well-dried, when it must be beaten with rods on wooden hurdles, to free it from the dye-stuff, which still hangs about it; or else the same effect is produced by putting it into a wool mill, formed of a four-flapped vane or fan thinly set with iron spikes, and swiftly revolving within a hollow cylinder, composed of small wooden rods or staves, sufficiently wide apart to suffer the dust to fall through, as the wool becomes slightly separated by the motion of the fans. It is then once more carefully picked, in order to take out the locks which are unevenly dyed, and also the lint, and other filth with which wool in this state generally abounds.

In making mixed cloths, wool of the different colours, being weighed out in their requisite proportions, are first shaken well together; they are then further mixed by being well turned in the wool mill, and by being afterwards twice passed through the scribbling engine instead of once, they are generally found to be sufficiently intermixed.

The wool, thus prepared, must now be spread abroad on a floor, and oil of olives (in the proportion of 3lb. to 20lb. of wool) evenly sprinkled over it, and beat into it with heavy rods, when it is in a proper state to be carried to the scribbling engine.

This is a machine composed of ten or more wooden cylinders, of various sizes, covered with cards, the teeth or wire of which are of different degrees of fineness, and bent or hooked in opposite directions. These are combined in a strong wooden frame, and so fitted as just to touch and work against each other, as they swiftly revolve on being set in motion by a com-

mon handle, adapted to be turned either by men's labour, or any sort of mill work. By passing through this engine, the locks of wool, which before were close and matted together, are drawn abroad, the fibres are separated, and it is formed into light flakes; it is then taken to the carder, which is a smaller engine of the same kind, only covered with finer cards, and with the addition of a fluted roller revolving in a trough at the tail of the machine; by which the wool, after being still finer and better mixed and carded, is formed, as it drops out, into separate and smooth rolls, of 28 inches long, and half an inch in thickness, which are immediately taken by boys, and joined or attached to the spindles of the roving or slubbing machine.

This is a contrivance, by which 50 or more iron spindles, being set upright in a wooden frame, are twirled by one motion, yielding their threads to a common slider, at every move of which the 50 rolls of wool are drawn out and formed into as many large slightly twisted threads, and at the same time wound off into balls of a size and shape adapted to the next operation, or spinning.

This is performed by a machine called the spinning jenny, which also is a frame containing 70 or more upright spindles, twirled like the former by a common motion, and yielding their threads to one and the same slider; by this the large hollow threads are further twisted and drawn out to the degrees of smallness and strength requisite for the different purposes for which they are designed. The threads, being thus spun, are reeled into skains and prepared for the loom. The larger sort, destined for the woof, are wound on spools, which are small tubes, so formed as to be easily placed in the eye or hollow of the shuttle. That for the warp is wound on large wooden bobbins, from which, by the warping bar, it is conveniently formed into the proper lengths and divisions, and so arranged and disposed as to form the chain or warp of the piece.

The chain, thus prepared, must be stiffened by a size, which is made by dissolving 3 lbs. of glue (the best sort of which is made from shreds of parchment) in a quantity of water sufficient to moisten and saturate the whole, and when dried it is ready to be turned on the loom.

In weaving broad-cloth there are two weavers in a loom, one on each side, who at the same time tread alternately on the same treadle, *i. e.* now on the right side and now on the left, which raises and lowers the threads of the warp equally, between which they throw, transversely, the shuttle from the one to the other. At each time that the shuttle is thrown (and so a thread of the woof inserted within the warp), they strike it conjointly with a moving frame, wherein is fastened the slay, which is a kind of comb, composed of thin pieces of cane, between whose teeth the threads of the warp are passed, repeating the strokes six or seven times with the warp open, and again as many times after it has crossed and closed on the woof. The whole warp being filled with woof, the cloth is finished.

Being next taken to the fulling-mill, it is there soaked with urine or hog's dung, and afterwards scoured with clean water; it is thus freed from the oil and filth contracted in dyeing, and delivered perfectly clean, in a state fit for the next operation, which is burling.

By this process (performed by women with little iron nippers) the cloth is cleared from all the knots, lint, small straws, and lesser filth; and if, by the carelessness of the spinner it contains any large uneven threads, they must now be gently taken out; and if any small hole or rent is made, it must be carefully drawn up, and mended with some of the warp-yarn of the same cloth.

But that compactness and density which distinguish woollen cloth from all other manufactures, and renders it so peculiarly adapted to our wear in these northern climates, is derived from the next operation, which is fulling, or milling, by which a cloth of 40 yards long, and 100 inches wide, being first sprinkled over with a liquor prepared from 5 lbs. of fine soap (made from the oil of olives) dissolved in hot water, is laid in the mill-trough, and there pounded or stamped on by two heavy wooden hammers, alternately raised and depressed by the cogs of a mill-wheel. By this process it becomes by degrees (generally in about 8 hours) so thickened and shrunk up, as to be reduced to 30 yards long and 60 inches wide, which renders it of the proper substance and thickness of common superfine cloth. During this operation, it must be taken out from the trough from time to time, to have more soap added, and to be smoothed from the wrinkles and creases which it would otherwise contract.

This faculty of being rendered thicker by compression, is peculiar to woollen substances. In vain may fabrics of silk or cotton be subjected to the same process; they would not, in any length of time, be rendered thicker by it, or more compact in the smallest degree. To account for this, it has been observed, that the single hairs of wool, when viewed in a micro-

scope, are discovered to be thickly set with rough and jagged protuberances, adapted to catch and entangle with each other. Whence it seems probable, that during the violent agitation the cloth undergoes in the mill-trough, the fibres being, at every stroke of the mill-hammer, strongly impelled together, and driven into the closest possible contact, at length hook into each other, drawing closer and closer as the process continues, till they become thus firmly and inextricably united; each thread, both of the warp and the woof, being so joined and compacted with those that are contiguous to it, that the whole seems formed into one substance, not being liable, like other fabrics, when cut with shears, to unravel and become ragged at the edges.

The cloth, thus milled to its proper thickness, must be scoured with clean water till it be perfectly free from the soap. In this part of the process, a preparation of fullers-earth and bullock's gall is found very serviceable, rendering the cloth at the same time soft and mellow.

The cloth must now be taken to the cloth-worker, in order to be dressed; which is performed by first properly drawing out, and arranging in one direction, all the hairs or fibres of the wool that can possibly be brought to the surface, and then shearing it as close as it will admit, without discovering the ground of the cloth, or laying the threads bare.

The instruments employed in this operation, are the wire cards, and teasils, to raise and draw out the hair, and the shears to cut off what is too long and superfluous. The teasil is a large kind of thistle, with the points growing very strong and hooked; to use them the heads are cut off, and set close together in small wooden frames called handles. These instruments, although hitherto worked by men's hands, with great labour and expense, have of late been so ingeniously adapted to machinery turned by mill-wheels, as to perform the same operation, with much more preciseness and effect, as well as great saving in point of expense, and the machines for this purpose are various, and continually improving. The method hitherto employed is generally as follows.

The cloth being drawn over a frame, constructed of boards laid sloping, and covered with hair-cloth, is, during its passage, in order to raise the wool, regularly scraped, or rubbed, from one end to the other, with the cards or teasils, being all the time kept as wet as possible by continually pouring water upon it. It is then laid on the shearing boards, which are made of wooden planks covered with coarse cloth, and forming a kind of hard cushion, where the wool thus raised is cut off with long heavy shears, which are pressed close to the cloth with leaden weights, and gradually slide forward at every motion or cut, till they have proceeded from one list to the other. The cloth is then returned to be again scraped or rubbed; these operations are repeated three times, every time with finer cards, or teasils, when the wool becomes sufficiently raised. It must now be taken to the rack, on which being fastened by the lists with small hooks or tenters, it must be drawn or strained thereon, until it be of an even breadth throughout; when dry it is returned to the shearing boards, on which the cutting is repeated three times more on the right side, and once on the other or back side. After this it is given to the cloth-drawers, who, having first, with small picking-irons, made very sharp at the points, drawn out all the small straws and bits of lint which have before escaped notice, carefully fine-draw or mend the small holes or rents, if any such have been made in it.

Nothing now remains to be done but pressing; preparatory to which, the cloth being doubled and laid in even folds, a leaf, or sheet of glazed pasteboard, is inserted between each fold or plait of the cloth; it is then laid in the press, and covered with thin wooden boards or fences, on which are laid iron plates properly heated, and on the whole (by means of a lever turning a screw) the top of the press is brought down, with the degree of force judged necessary to give it the proper gloss. When cold, it may be taken out of the press, in order to be folded and packed, ready for sale.

Manufacture of Colours. See Colour-making.

Manufacture of Copperas. See Copperas, Iron.

Manufacture of Combs.—Combs are generally made of the horns of bullocks, or of elephants' and sea-horses' teeth: some are made of tortoise-shell, and others of box or holly woods. Bullocks' horns are thus prepared in order to manufacture combs: the tips are first sawn off: they are then held in the flame of a wood fire; this is called roasting, by which they become nearly as soft as leather. While in that state they are slit open on one side, and pressed in a machine between two iron plates; they are then plunged into a trough of water, from which they come out hard and flat.

The comb-maker now saws them into lengths according to the sized combs he

wants. To cut the teeth, each piece is fixed in a tool called a clam. The teeth are cut with a fine saw, or rather a pair of saws, and they are finished with a file. A coarser file called a rasp, is used to reduce the horn to a proper thickness; and when the combs are made, they are polished with charcoal and water, and receive their last finish with powder of rotten-stone.

The process used for making ivory combs, is nearly the same as that already described, except that the ivory is first sawed into thin slices. The best ivory comes from the island of Ceylon and Achen, in the East Indies, since it has the property of never turning yellow: of course, the ivory from these places is much dearer than that brought from other parts.

Having described the usual method of making combs, it is right to inform the reader, that about eight years ago, a patent was obtained for cutting combs by means of machinery. Mr. Pettibone also obtained a patent for a similar purpose: it was carried into effect in Massachusetts. It will be thought a very singular circumstance, that, before this period, no method was practised for cutting the teeth of combs, but that in which a pair of saws, rudely fastened in a wooden back, was directed by the human hand. With these implements, however, it is, that the very delicate superfine ivory combs, containing from fifty to sixty teeth in an inch, are manufactured.

By the machine the business of comb-making is greatly expedited; the teeth of two combs may be cut in about three minutes. The combs are afterwards pointed by applying them to an arbor or axis clothed with cutters having chamfered edges and teeth. See 11th vol. *Repertory of Arts*, for a description of this machine.

Tortoise-shell combs are very much used, and there are methods of staining horn so as to imitate tortoise-shell; of which the following is one:—The horn to be dyed must be first pressed into a flat form, and then spread over with a paste made of two parts of quick-lime and one of litharge, brought into a proper consistence with soap-ley. This paste must be put over all the parts of the horn, except such as are proper to be left transparent, to give it a nearer resemblance to tortoise-shell. The horn must remain in this state till the paste be quite dry, when it is to be brushed off. It requires taste and judgment to dispose the paste in such a manner as to form a variety of transparent parts, of different magnitudes and figures, to look like nature. Some parts should also be semi-transparent; which may be effected by mixing whiting with a part of the paste, to weaken its operation in particular places; by this means spots of a reddish brown will be produced, so as greatly to increase the beauty of the work. Horn thus dyed is manufactured into combs, and these are frequently sold for real tortoise-shell. See HORN.

Manufacture of Cotton: one of the leading and most important branches of our national industry. On arriving at the cotton-mill the bags are unpacked, and the contents examined, at the same time it is turned over and beaten with a stick, and the gross impurities picked out with the fingers. This is called sorting, and the object of the beating is to soften and open the fibre of the cotton, so as to expose every part. The sorting is performed immediately when the bags of cotton are opened, but it has still to undergo a second examination, called picking; the principal object of the first examination, or sorting, being intended to ascertain the quality of the cotton, and to find what kind of goods it is best adapted for manufacturing, and in this examination the coarsest impurities and yellow damaged parts are picked out.

After sorting the cotton, it is carried to the batting machine, and the coarser sorts of cotton to the opening machine, which is known to the workmen by the name of devil. In the batting machine, the cotton is spread upon a platform of ropes strained very tight, and a number of rods strike very smartly upon it, by which they open the fibres and loosen the knots of cotton preparative to the succeeding operations: at the same time the violence of the batting loosens and shakes out all dirt, dust, and cotton seeds, of which the cotton in its raw state contains a great number, and which would be very prejudicial to the operations of the more delicate machines. The cotton, when first packed up in the bags, is compressed very closely, for the convenience of stowage, and this condenses it into a hard matted mass; but the batting machine, striking it violently with small sticks, causes the fibres, by their natural elasticity, and the motion occasioned among them, to gradually loosen and disengage themselves, and the cotton, by repeated strokes, recovers all its original volume.

The opening machine has the same objects, and produces the same effects, though in a very different manner, as it consists of a rapidly revolving cylinder, on which a great number of iron teeth, or spikes are fixed; which tear and open the cotton against other similar teeth, which

are fixed in a stationary half cylinder or hook, enclosing the other. The batting machine is used for the finer kind of cotton; and the opening machine, which acts in a more rapid though less effective manner, is employed upon the coarser sorts. After batting or opening, the cotton is again picked, to remove those finer particles of dirt which were before enveloped in the cotton, but are exposed hy the operation of the machine. It is performed by women, who remove all extraneous matter, and every particle of yellow or damaged cotton. The perfection of the article to be produced, depends in a great degree on the care with which the picking is performed, and this is almost the only process in the cotton spinning, which cannot be performed by machinery, because it necessarily requires a discretionary power.

The cotton wool being picked clean, is next mixed; that is, the contents of different bags are mixed together with a view of obtaining a similarity in the quality of the cotton which is to be spun. In this operation the greatest art of cotton-spinning consists, and it is that department in which experience alone guides the manufacturer. By a judicious mixture of different sorts of cotton, some spinners will produce a very fine and capital yarn, from such cotton as would, if spun alone, or improperly mixed, only produce coarse and low priced goods. The mixture is effected by making a pile or heap, consisting of successive layers, of the different kinds of cotton which are to be mixed; then by raking away a small quantity at a time from the edges of the heap, striking the rake from the top to the bottom, through all the different layers, the cotton will be very equally mixed. Sometimes the cotton wool is dyed, and different colours are mixed together. It is now spread out, very evenly and regularly, upon a long cloth, which is rolled up and carried to the

Carding machine.—This consists of a number of cylinders, covered with wire teeth or cards, and revolving with considerable velocity in opposite directions, nearly in contact with each other, and covered by a dome also lined with cards. The cotton, being introduced among these, is continually combed, or carded, by the teeth, until almost every individual fibre is separated and drawn straight, and every little knotty and entangled part disengaged. By passing gradually through the machine from one cylinder to another, the cotton is dispersed lightly and evenly among the teeth over the whole surface of the last, or finishing cylinder, from which it is detached by the mechanism in a continued fleece. This is drawn off, and lapped upon a cylinder turned slowly round by the machine, until the fleece has made a great number of turns upon the cylinder: it is then broken off, by dividing it at one part, so that it forms a fleece called a lap, which is the length of the circumference of the cylinder, and consisting of fifteen or twenty thicknesses; by which admirable contrivance very great regularity is obtained in the thickness of the lap, because if any one part of the fleece produced by the machine is thinner or thicker than it ought to be, in consequence of any irregularity in the spreading of the cotton-wool upon the cloth, previous to carding, such irregularity will have no sensible effect upon the ultimate thickness of the lap, because it is composed of thirty or forty strata, and there is no probability that the inequalities of these several strata will fall beneath each other, but every chance that they will be equally dispersed through the whole, and thus correct each other. The lap, when taken off, is laid flat on a cloth, which, with it, is rolled up and conveyed to a second carding-machine, called the finishing card, while the first is called the breaker. In this second card it undergoes a similar process to the first, but instead of the fleece being received on a cylinder, it is contracted by passing through a funnel, in which the fleece, being hemmed in on both sides, is gradually contracted to a thick roll, which may be continued to any length as long as the machine is supplied with cotton. This roll or band of cotton is drawn off between two rollers, which compress it into a pretty firm, flat ribband, about two inches broad. The rollers deliver it into a tin can placed to receive it, and in this it is removed to the

Drawing Frame.—This machine consists of several pairs of rollers, between which the cotton is passed, and every successive pair it is drawn through moves, by means of the wheel-work, with a greater velocity than those preceding it, so as to stretch out the band or sliver of cotton, in the same manner as it would be drawn out, if one part of the sliver were held between the finger and thumb of one hand, and another part, at an inch or two distant, being held in the other hand. Then, by drawing the two hands asunder to the extent of four inches, it is evident two inches in length of the cotton sliver would be extended or drawn out to four inches. In like manner, the first pair of rollers through which the sliver passes, are pressed together with a sufficient weight to hold the cotton firmly between them.

The second pair of rollers are situated at one or two inches distant, and are made by the wheel-work to revolve more swiftly than the first. The difference of velocity, however, is but small, though the consequence is, that the sliver will be lengthened in the same proportion ; for the second rollers take up the cotton much faster than the first pair will deliver it out : it must, therefore, be either forcibly pulled through between the first rollers, or it must be stretched a little, by the fibres slipping among each other, or it must break. When the extension is small, the only effect of it is merely to begin to draw the fibres (which are at present lying in every possible direction) into a straight and parallel position, which is most favourable for the subsequent extensions. The drawing frame contains a third, and some of them a fourth pair of rollers, by which the sliver undergoes a second or third draught; but the combined effect of all these drawings is generally to extend the sliver to four times the length it was when first put to the machine. But as this would reduce the sliver to one-fourth of the size, which is not intended in this stage of the process, four ends or slivers are introduced between the rollers together, and being drawn into one, which is four times the length, it will of course be of the same size as any of the four which is put in. This drawing process is repeated three or four times, and the alteration it makes in the cotton is to equalize the size of the sliver, on the same principle as before described of the breaking card, viz. by repeatedly combining four together, and drawing them into one : it also disposes the fibres longitudinally and in the most perfect state of parallelism. The operation of carding effects this in a certain degree ; yet the fibres, though parallel, are not straight, but many of them doubled, as may easily be supposed, from the teeth of the cards catching the fibres sometimes in the middle, which become hooked or fastened upon them.

Though the general arrangement of the fibres of a sliver from the finishing card is longitudinal, yet they are doubled, bent, and interlaced in such a way, as to render the operation we are now speaking of absolutely necessary

When the cardings have been passed four or five times through the drawing frame, every fibre is stretched out at full length, and disposed in the most even and regular direction ; so that each fibre will, when twisted into a thread, take its proper bearing, in consequence of every one being straightened and having the same tension.

The sliver in this state presents a most beautiful appearance, being so extremely regular in its size, and all the fibres drawn so straight, that it bears a fine glossy or silky appearance. It is upon this sliver or ribband of cotton wool that the operation of spinning begins. The general effect of the spinning process is, to draw out this massive sliver, and to twist it as it is drawn out : but this is not to be done by the fingers, pulling out as many fibres of the cotton at once as are necessary for composing a thread of the intended fineness, and continuing this manipulation regularly across the whole end of the ribband, and thus, as it were, nibbling the whole of it away. The fingers must be directed for this purpose by an attentive eye ; but in performing this by machinery, the whole ribband must be drawn out together and twisted as it is drawn. This requires great art and very delicate management : it cannot be done at once, that is, the cotton roll cannot be first stretched or drawn out to the length that is ultimately produced, from the tenth of an inch of the sliver, and then twisted. There is not cohesion enough for this purpose, it would only break off a bit of the sliver, and we could make no further use of it ; for the fibres of cotton are very little implicated among each other in the sliver, because the operation of carding and drawing has laid them all parallel in the sliver ; and though compressed a little, by its contraction in the card from a fleece of twenty inches to a ribband of two, and afterwards compressed between the rollers of the drawing frame, yet they cohere so slightly, that a few fibres may be drawn out, without bringing many others along with them. For these reasons, the whole thickness and breadth of two or three inches are stretched to a very minute quantity, and then a very slight degree of twist is given it, viz. about two or three turns in the inch, so that it shall now compose an extremely soft and spungy cylinder, which cannot be called a thread or cord, because it has scarcely any firmness, and is merely rounder or slenderer than before, being stretched to about four times the former length. This is called roving, and the operation is performed in the

Roving Frame.—This machine is constructed in a great variety of forms, but all of them have the same object in view, viz. to draw out the sliver, so as to reduce it from a large band to a coarse and loose thread ; but as this extension would render it so extremely tender, that it would scarcely hang together in passing through the succeeding machines, the roving

frame, immediately after having drawn and extended it to the intended size by rollers, operating in the same manner as the rollers of the drawing frame, gives it a very slight twist, as before mentioned, and this loose thread, which is called the roving, is the first rudiment of a thread. Although it is extremely tender, and will not carry a weight of two ounces, it is much more cohesive than before, because the twist given to it makes all the longitudinal fibres bind each other together, and compress those which lie athwart: therefore it will require twice the force to pull out a fibre from among the rest, but still not near enough to break it. In drawing a single fibre others are drawn out along with it, and if we take hold of the whole assemblage in two places, about an inch or two asunder, we shall find that we may draw it to near twice its length, without any risk of its separating in any intermediate part, or becoming much smaller in one part than another. It seems to yield equally over all parts.

Our readers will now perceive, that these processes will ensure all that is wanted, and prepare a roving that is uniform, soft, and still very extensible: in short, fit for undergoing the last treatment of spinning, by which it is made a fine and firm yarn.

It is evident that the roving produced by these operations must be exceedingly uniform The uniformity really produced exceeds all expectation; for even although there be some small inequalities in the carded fleece, yet if these are not matted clots which the card could not equalize, but only consist of a little more thickness of cotton in some places than in others, this inequality will first be diminished by the lapping of the fleece in the breaking card; and when such a part of the sliver comes to the first roller of the drawing frame, it will be rather more stretched by the second than a thin part would be. That this may be done with greater certainty, the weights of the first rollers are made very small, so that the middle part of the sliver can be drawn through, while the outer parts remain fast held.

Such is the state of the roving as prepared by the roving frame. All the preceding processes are to be considered as the preparations: and the operation of spinning is not yet begun. These preparations are the most tedious, and require more attendance and hand-labour than any subsequent part of the process. For the slivers from which the rovings are made are so light and bulky, that a few yards only can be piled up in the cans set to receive them from the carding and drawing: a person must therefore attend and watch each roller of the drawing and roving frames, to join fresh slivers as they are expended. It is also the most important department in the manufacture; for as every inch will meet with precisely the same drawing and same twisting in the subsequent parts of the process, therefore every inequality and fault of the sliver, indeed of the fleece as it quits the finishing card, will continue through the whole manufacture, in a greater or lesser degree; being only diminished, not corrected, by the drawing, doubling, &c. The spinning of cotton-yarn now divides itself into two branches. The first performed by what were called jennies, when worked by the hand, but since they are moved by the power of a mill, they are called mules: the manner of action resembles the ancient spinning with distaff and spindle. The second method, called spinning of twist, or water-spinning, because it was the first spinning performed by a water-wheel, is in imitation of the spinning with the fly-wheel, or jack and flyer. The two methods differ in the same manner, as the old wool or cotton-wheel differs from the spinning with the flax wheel. Mr. Arkwright's chief invention, the substitution of the machinery for the immediate work of the human finger, was at first only applied to the manufacture of twist, or water-spinning. We shall, therefore, first direct our attention to this.

The water-spinning process is little more than a repetition of that gone through in making the first slivers or rovings, which are formed on bobbins, either by the roving frame, or are afterwards bound on bobbins by the hand. These bobbins are set on the back part of the

Spinning-frame, in which the roving is drawn, and extended to any required degree of fineness; and the proper twist being given to it, forms it to the required thread. The spinning-frame is provided with systems of rollers, in the manner of the drawing-frame, through which the roving passes, and is drawn out according to the size of the thread which is required to be spun, which varies from four to seventeen times; and it is then twisted more or less, as the thread is required to be hard or soft: therefore, the spinning process scarcely differs from the roving, except in the twist that is given it, after the last stretching, in its length. This is much greater than the roving, being intended to give the yarn hardness and firmness, so that it will afterwards break rather than stretch any more. The perfection of the ultimate thread or yarn depends, in a great measure, on the extreme softness of the roving; for it is this only which makes it susceptible of an

equable stretching, all the fibres yielding and separating alike; and this property will be greatly influenced by the quantity of twist given by the roving-frame. For these points no very distinct rule can be given: it varies in different mills, and with different species of cotton wool, as may be easily imagined. The immediate mechanism, or manipulation, must be skilfully accommodated to the nature of that friction which the fibres of cotton exert on each other, enabling one of them to pull others along with it. This is greatly aided by the contorted curled form of a cotton fibre, and a considerable degree of elasticity which it possesses. In this respect it greatly resembles woollen fibres, and differs exceedingly from those of flax; and it is for this reason that it is so extremely difficult to spin flax in this way: its fibres become lank, and take any shape by the slightest compression, especially when damp in the slightest degree. But besides this, the surface of a cotton fibre has a harshness or roughness, which greatly augments their mutual friction. This probably is the reason why it is so unfit for tents, and other dressings for wounds, and is refused by the surgeons even in the meanest hospitals. But its harshness and elasticity fit it admirably for the manufacture of yarn. Even the shortness of the fibre is favourable; and the manufacture would be very difficult, if the fibre were thrice as long as it generally is. If it be just so long that, in the finished thread, a fibre will rather break than come out from among the rest, it is plain that no additional length can make the yarn any stronger, with the same degree of compression by twining. A long fibre will indeed give the same firmness of adherence, with a smaller compression by twining. This would be an advantage in any other yarn; but in cotton, the compression is already as slight as can be allowed: were it less, it would become woolly and rough by the smallest usage; and it is already too much disposed to teasle out. Now, suppose the fibres much longer, some of them may chance to be stretched along the sliver through their whole length. If the sliver is pulled in opposite directions, by pinching it at each end of such long fibre, it is plain that it will not stretch till this fibre be broken up, or drawn out; and that while it is in its extended state, it is acting on the other fibres in a very unequable manner, according to their positions, and renders the whole apt to separate and draw more irregularly. This is one great obstacle to the spinning of flax by similar machinery.

Mule-spinning.—A great proportion of the cotton is spun in the mule instead of the water-frame. The preparation it undergoes for either method is the same; at least the processes are similar, except that the quantities of draft, and some other particulars, may be varied in the preparation of the cotton which is to be thus spun in this machine, which is called a mule, either because it is a kind of machine which might easily be turned by a mule, or more probably because it is a sort of mongrel, partaking of the nature of both drawing and spinning, or uniting the action of both the roller and spindle. It consists of three sets of fluted brass rollers, the flutes of which turn into each other. The first set goes faster than the second, and the second faster than the third; between which when the sliver of carded cotton enters, it is a little lengthened out between the first and second, and farther still between the second and third; after passing which, it is slightly twisted by the rapid circular motion of the spindle. This has the same effect as the spinning-frame; but the quantity of draft between the rollers, or extension of the sliver, is not, like the water-frame, to the full extent which the thread is intended to be. The remainder of the stretching is performed in this manner; the spindles of the mule, which give the twist to the thread, are fitted in a frame, so that they can be moved backward and forward, in a straight line, to and from the rollers; a certain length of the roving being therefore given out by the rollers, the spindles are removed backward to take it up as fast as it comes, and in this motion they twist it slightly: at the same time, but after a certain quantity of the roving, a yard for instance, has been given out by the rollers, their motion ceases; but the spindle continues to recede from them, another half yard for instance, continuing to twist the thread all the while. By these means, it is evident that the thread will be stretched from a yard to a yard and an half in length: by this contrivance, the cotton will bear a greater degree of extension than any other, because it is constantly twisted at the same time that it is extended in length.

The invention of mules forms quite an epoch in the history of the cotton trade. A vast improvement was made, about 35 years ago, by the introduction of the spinning jennies, by which from twenty to forty spindles were turned at a time. The spindles were the same as the mule, and had the same motion; but this machine was not provided with rollers to draw out the cotton, previous to twisting, merely depending upon the stretching, to give it

the proper extension requisite to form the roving into a thread. But the combination of the jenny with sir Richard Arkwright's invention of drawing, by rollers, forms a method superior to both, at least for fine goods. The method of stretching gives the means, as we have before mentioned, of very great extension; but if this be carried so far as to draw out the coarse loose roving to a fine thread, there will be great danger of its drawing irregularly, that is, more in one place than another. In the original method by the jenny, the rovings were prepared by the hand-wheel: they were loose, coarse, untwisted threads, partaking somewhat of the nature of cardings, though approaching in some degree to spun twist. They were obliged to be prepared by the hand-wheel, because the cardings, which were prepared by hand-cards, were in detached pieces of a certain length, and regularly tapering towards each end: the joining of these together, in such a manner as to produce an equal and regular roving, required a care and attention which could not be effected by machinery.

The combination of sir R. Arkwright's system of preparation with the jenny produced the mule, which, without the defects of its original, spins in the most expeditious and perfect manner. The advantage of this mode of preparing the threads over that of the jenny is, that the fibres of the cotton are all laid longitudinally, and nearly in as small number as is wanted, before they are begun to be much twisted; by which means, threads of any required fineness are made much stronger than they were from rovings, made upon the spindle of the hand-wheel spun in the jenny, which twisted them too much in the first instance; and in the subsequent extension or stretching, by the removal of the spindle, for rendering them finer, many of the fibres were necessarily broken. On one of these mules 240 threads are often spun at once; and two of them may be managed by one woman, with a child to tie the threads which may occasionally break.

The reader moderately acquainted with mechanics, cannot but perceive, that by each of the operations now described, the cotton-wool is prepared, and drawn into a fine strong thread by repeatedly drawing the sliver till its fibres become straight, then reducing it in the roving frame to a coarse thread, and by a slight twist giving it sufficient strength to bear such an extension as will reduce it to the size intended, and then it is immediately twisted into a hard thread. All these processes are only a substitute for a single pull of the finger and thumb of the spinner, which she accommodates precisely to the peculiar condition of the lock of wool which she touches at the moment: she can follow this through all its irregularities, and, perhaps, no two succeeding plucks are alike. But when we cannot give this momentary attention to every minute portion, we must be careful to introduce the roving in a state of perfect uniformity, and then every inch being treated in the same manner, the final result will be equable, and the yarn will be uniform.

The thread being now finished, either by the water-frame or mule, it is carred to the

Reel, by which it is taken off the bobbins of the spinning-frame, or the cops of the mule, and formed into hanks. The hank is a measure in cotton trade, composed of seven leys, each of 120 yards in length. The reel, or frame round which the thread is wound is one yard and a half in circumference, and at every 80 turns (or bouts) which it makes, the 80 turns of the thread are tied together to keep them separate, and this measures out 120 yards, which is called a ley, but the thread is not cut at the ley, it is continued to be wound on the reel, till seven such leys, or 840 yards, are reeled: it is then cut and called a hank, which is tied up.

The different sizes of cotton yarn, or thread, are denominated according to the number of these hanks which will weigh a pound. The hank of 840 yards in length is the measure used in all English cotton-mills, and thus affords a very accurate and convenient standard for the size of the cotton. The number is ascertained by weighing each individual hank in a little weighing instrument, which shews by an index what number of such hanks will weigh a pound Each hank being twisted up is suspended on the hook of this instrument, and the number being ascertained, the hank is put on a proper shelf till they are all sorted. Then, by a table on purpose, it is seen how many hanks of any number will weigh 10 lbs. and this number being counted out from any one shelf, is packed up in the bundling press, and tied in papers, marked, and sent away for market. Sometimes, the cotton intended for weaving is warped in the warping-mill before it is sent away from the mill: this saves the weaver an immense deal of trouble.

Some of the twist is wound on quills for the shuttle; and others, again, are formed into hanks, some of which are tightly bound round at certain intervals previous to their being dyed, in order to prevent the parts so tied from taking the

colour. This is done that the threads may be disposed to warp in the weaving loom, so as to produce the clouds which are seen in various species of the cotton goods, especially ginghams.

Some of the cotton thread is dyed in the hank, and other cotton which is intended for sewing, knitting, &c. or to weave fine goods, is bleached; and because in this process, or in dyeing, some shrinking takes place, it is wound from the hanks upon bobbins again by the winding machine, and from these bobbins it is again reeled into hanks, in which it is packed up and sent to market: other cotton thread for sewing, mending, and domestic use, is wound into balls of a figure resembling a cask, and the many intersections of the thread are so managed as to produce a very beautiful appearance.

The denominations of the quality of the different kinds of cotton threads are chiefly divided into yarn and twist, and this is called mule twist, or water twist, as it is spun either in the mule or water-frame. That thread which is denominated water-twist, is used for weaving calicoes, &c. It is spun hard, that is, with a great deal of twist, so that it forms a strong hard thread. It is manufactured of all numbers, from 10 to 60 hanks per pound.

The mule-twist is used for weaving muslins and the finest cotton goods. The essential difference between this and the water-twist are, that the mule produces much finer articles than are attempted on the water-frame, at the same time it makes a softer thread. As it requires much less power to work it than the water-frame, the manufacturer spins every thing in the mule which will admit of it; but it will only produce the soft kinds of thread. The mule will spin all numbers, from the lowest to 150 or 170 hanks per lb.

Stocking yarn is spun softer than twist, and two threads are afterwards doubled together in the doubling machine, and then slightly twisted round each other in the twisting machine. Sometimes one of the threads is dyed black, or blue, before the twisting, and then it produces a speckled thread, which is called one-thread white. This yarn is chiefly used in the stocking-frame; it is spun in all numbers, from 10 hanks in the pound up to 60. The threads of stocking-yarn are but slightly twisted, so that its composition of two threads is always distinctly visible.

Sewing cotton is made either from twist or cotton yarn doubled, and twisted very hard together by passing it a second time through the spinning frame, so as to form a strong thread, which may be compared to a small rope, as the two threads make one very compact and defined thread.

Mending cotton is the same as sewing, but of less twist: indeed the distinction is trifling.

Knitting cotton is twisted with two or three threads, but not so hard twisted as sewing cotton, though it is harder than mending. This cotton is frequently bleached after it is twisted.

Candlewick cotton is a very loose coarse thread, made from the cheapest and most inferior kind of cotton: being only intended for the wick of candles, no great care is used in the manufacturing. A great deal of candlewick is made from tow which is bleached, and makes an article something like the cotton in appearance, but by no means equal to it in quality. This is known by the cant term of bump, and many large mills are employed in spinning it. The cotton candlewick is known by the name of Turkey, which is made from Smyrna or other cheap inferior kinds of cotton. It is spun generally about $10\frac{1}{2}$ to 11 hanks per lb., and sent off to market wound up in large balls.

To pursue the progress of the cotton after being spun into twist, we must remove from the cotton-mill to the cottage of the weaver. Here, the warp being fixed in the loom, or, in the language of the weaver, warped, it is divided to give passage to the weft in the shuttle, either by two, three, or more treadles: or if the pattern or course of changes in the order of raising and depressing the threads of the warp be various, so that the weaver could not manage the requisite number of treadles, it is done by a great number of strings which pass over pullies above the loom, and are drawn one after another by a little boy, above whose head they are disposed in two rows by the sides and between two looms. These looms are, therefore, called draw-boys. These boys will shortly be set aside for machinery, which is rapidly introducing a substitute. For the formation of sprigs, &c. of various colours, there are often as many shuttles as colours, or a number of little swivel looms, such as they use for the weaving of tapes, introduced occasionally, as many as there are sprigs in the breadth of a piece. Quiltings appear to be two distinct cloths, tied as it were together by ditches, which go through both cloths, and in some cases, as in bed-quilts, there is a shuttle which throws in a quantity of coarsely spun cotton, to serve as a kind of wadding. The counterpanes are woven with two shuttles, one containing a much coarser weft than the other; the coarser

of the threads is picked up at intervals with an iron pin, rather hooked at the point, so as to form knobs disposed in a sort of pattern.

When the goods have come from the loom, most sorts of them, previously to being bleached, are fired or dressed, by being drawn, and that not very quickly, over red-hot cylinders of iron, by which the superfluous nap is burnt off. To see such an operation performed upon so combustible a substance, naturally fills a stranger with the utmost concern and astonishment. They are then washed in a wheel with soap and water, and having been well scoured with an alkaline lixivium, are dipped in the oxygenated muriatic acid, diluted to its proper strength. These preparations are repeated alternately, till the goods have attained the requisite whiteness; and between each dipping they are laid out upon the ground, and exposed to the action of the sun and air. When completely bleached, they are either smoothed upon long tables with smoothing irons, or calendered; that is, stretched and pressed between a course of rollers, by which they acquire a fine gloss. Calicoes are printed exactly in the same way as the kerseymeres, but the works are usually upon a much larger scale. See PRINTING.

Thicksets, corduroys, velveteens, &c. are cut upon long tables, with a knife of a construction somewhat like the sting of a wasp, terminating in a very sharp point, defended on each side by a sort of sheath. This point is introduced under the upper course of threads which are intended to be cut, and with great ease carried forward the whole length of the table.

The rapid increase of the cotton trade in England appears to have been owing, in a great measure, to the more liberal introduction of machinery into every part of it, than into any other of their staple manufactures. The utility and policy of employing machines to shorten labour, has been a subject which has exercised the pens of many ingenious writers, while their introduction into almost every branch of manufacture has been attended there in the outset with much riot and disorder. They are undoubtedly wonderful productions of human genius, the progressive exertions of which neither can nor ought to be stopped; they enable a manufacturer to produce a better article than can be made by the hand, in consequence of the uniformity and certainty of their operations, and at a much lower price, in consequence of the vast quantities of goods they are capable of performing. And although they do, undoubtedly on their first introduction, throw some persons out of employ, by changing the nature and course of business, they almost immediately make up for the inconvenience by astonishingly multiplying the absolute quantity of employment. If they have taken away work from carders and spinners, they have returned it them back tenfold, as winders, warpers, weavers, dressers, dyers, bleachers, printers, &c.

It is this machinery which we have now to explain. An extensive cotton mill contains most interesting specimens of human ingenuity and resource, and shews in a striking manner what may be done, when the talents of a great number of individuals are directed to one common object, and where the most trifling part is of such importance (from the frequent repetition of it which is necessary) as to become worthy the consideration of the manufacturer to devise machinery for accomplishing it in a better or cheaper manner. There is in the cotton trade in England such a spirit of improvement, that they have, as a body, less prejudice in favour of old established customs than perhaps any other class of men; this is doubtless a reason of the great perfection of their art, as they have made trials of new ideas, without those years of reflection which men in other trades require before they will venture to embark in any new improvement, though ever so promising and favourable in appearance.

Our readers, who are unacquainted with the subject, will now by this sketch have obtained such a general idea of the cotton manufacture, as will enable them to comprehend the technical terms which are necessary to be used in the subsequent explanation of the machinery, and those references which must sometimes be made from one process to another. A large cotton mill is generally a building of five or six stories high: the two lowest are usually for the spinning frames, if they are for water twist, because of the great weight and vibration caused by these machines. The third and fourth floors contain the carding, drawing, and roving machines. The fifth story is appropriated to the reeling, doubling, twisting, and other operations performed on the finished thread. The sixth, which is usually in the roof, is for the batting machine, or opening machine, and for the cotton pickers, who, for a large mill, are very numerous. This last is not always so occupied, many manufacturers thinking it better to have out-buildings for these parts of the process, and only to have such parts in

the mill as require the aid of the large water-wheel, or steam-engine, which turns the whole mill. If the mule is used for spinning instead of the water-frame, then the cards are usually put below, because they are then the heaviest and most powerful machinery.

The following notes on the subject of arranging Cotton Machinery, have been communicated by a very intelligent gentleman of Philadelphia, who collected them with a view of obtaining the information necessary to embark in the business.

We give them in the manner they were originally written, lest in attempting to systematize them, we might render them less intelligible.

1. The following description is designed to apply to run 1000 spindles.

2. Power required—90 spindles in water frames are considered the work of a one horse power, this includes all the work of previous apparatus for carding, roving, twisting, doubling, &c &c. Water frames are so called, because they were the first invention for spinning by water. Spindles are also hung in throstles, which is a mode of applying the power to more advantage; but it is not durable in regard to the machinery, but is erected at less expence. They are also hung in mules, which may be worked by hand or water, but it is not perpetual spinning. A one horse power would turn 120 spindles in throstles, and 260 spindles in mules. The cotton spun in water frames is the best for the chain, and in the mules for the filling the proportionate price of cotton yarn, in England, was commonly as follows:—When No. 15, sold at 4*s*. 6*d*. per pound sterl. spun on mules—No. 15, or 15 skeins to a pound, water twist, would bring 5*s*. 6*d*. The water twist is much harder, and the mule twist much softer.

3. A paper-mill engine requires a ten horse power. Hence, the power which would turn an engine, would turn 900 spindles in water frames, 1200 in throstles, or 2600 in mules, with all the necessary accompanying apparatus.

4. Water frames and throstles, if equally well made, will spin equally well all the Numbers, from No. 6 to No. 40, or No. 44, finer than the last is done by mules—which stretch the yarn after it has received part of the twist, and then give it more twist. Coarser than the lower number, down from No. 6 to No. 1.; which last is coarse candle wick, is made by spindles in mules, called stretchers.

5. The cost of erecting the whole apparatus, to include the carding, drawing, roving, spinning, and reeling, is generally averaged on the spindles. The carding, &c. is the same cost, let whatever spindles be used—but, if water frames are used, the cost will be about eighteen dollars per spindle; if throstles, the cost will be about $16.75; and, if mules, perhaps a little less.—the above includes every thing, except for the manufactory and moving power. The moving consists of the water wheel and great cog wheel, to turn an upright shaft; after this come the drums, which are three feet diameter for throstles, and mules and cards, and move 45 times in a minute—and for water frames, the drums run horizontal, are 4 feet 4 inches in diameter: they are thus calculated to afford the velocities required by each description of machinery to move together—for water frames, the drums turn 36 times per minute—the difference between the velocities of the drums for the throstles which move 45 times in a minute, and that of the drums for the water frames which move 34 to 36, is made by the wheel work from the several horizontal shafts which receive motion from the upright.

6. In regard to the house or manufactory, it is always necessary that it should be built 4 stories high, and 5 stories are better—the work to be distributed as follows:

1. The upper stories are occupied by the carding and roving work.

2. The next to the upper for the same.

3 and 4. For spinning.

5. The lower story for reeling and hacking—the carding and spinning will not do well together on account of the dust.

The best width of a house is from 36 to 38 feet wide in the clear—the length of a building for 1000 spindles, if 4 stories high, will require 36 feet long; the stories if for throstles or mules, must be 10 feet high—the carding rooms in any case, must be 10 feet; but the machinery for water frames will be suited very well at 8 feet high.

7. The only heat required is for warming the mill, and there is no other risk of fire than what arises from this cause, or from the lighting it for work at night —however, all must be excepted which arises from friction, or the slipping of bands—which is very little or none, if care is taken.

8. Cotton will not spin unless the heat is supported to 48 degrees, and upwards —and all damp must be guarded against.

9. In mills of common lengths, the power is always applied from the end to an

upright—the upright goes through the several stories coupled together at each; but if the length is very great, the water wheel is generally at the side.

10. It would require 12 months to erect 1000 spindles.

11. It would require 5 children to every 100 spindles; or 50 children, or 40 children and 2 or 3 women to 1000. Four men would be necessary in addition—1 for an overseer, 1 for the spinning master, 1 for a carding master, and 1 for the packing and sending away.

12. A machine house ought to be built 2 stories high, 30 feet long by 28 feet wide, to erect and build the machines in.

13. The description of children to be employed, is from the age of 6 to 14 years, male and female, indiscriminately; some stout children as young as 4 years, have been employed: but the best age is the medium 9 to 12. The employment of the youngest children is to wind the rovings on spools—the next class are employed in attending the roving frames and the carding machines, and in taking the rolls from the cards, and setting them under the drawing frames—the next class are employed in attending the water frames or the throstles, the object is to piece the ends when the cotton breaks on the spindles—the elder class is employed in reeling the cotton from the bobbins, and in doubling and twisting it if required; frequently young women are employed for this business. A day's work is commonly called 11 hours: this allows time only for their meals—the work is every day in the week. It is sometimes the practice to work only 10 hours, and give schooling for 2 or 3 hours. At the manufactories in New-York, (Stone & Dyson) they take the children from the Poorhouse, and find them compleatly; employ them 10½ hours, and school them 2½ hours. In winter, work is begun early enough in the morning to accomplish the day's work; and there is considerable advantage obtained to the work by the lighting of the candles. It is observed that, when the candles or lamps are lighted at night, the facility with which the work moves is so much more as to require water to be taken from off the wheels—there is greater advantages beyond this, in beginning early in the morning, in saving the risk from fire.

14. The speed of the work is regulated by a clock, having one generally in the counting-house, and a shaft running through to a plate near it, having a reduced motion to keep the speed properly.

15. One hundred spindles may be set to work at the proportionate expence of 1000, say for $1800—but not less than 100 spindles, for 100 spindles is required.

One set of cards, viz. one breaker and one card.

One set of frames, viz. one stretching frame, and one roving frame

One throstle would hold 100 spindles, and in this case it would cost only $1675.—There is, however, enough of the carding and roving apparatus to suffice for 2 water frames which would run 72 spindles, each 144.

16. On the same water frame or throstle, yarn may be spun from No. 10 to 20, or from 20 to 30, or 30 to 40; but not No. 10 to 40, on one frame, nor a greater variation than 10 numbers. The yarn usually wanted in this country, is from No. 12 to 20. The yarn from 10 to 20, is the most profitable, and is of very little difference in profit.

17. Yarn is spun by machinery in England, to No. 160—to No. 260, for extreme fine cambric muslin. To have the most careful persons and spin the very finest yarn, is the most profitable.

18. I cannot tell what quantity of yarn is spun per day by the spindles, but the coarsest spins the greatest weight. The prices of the yarn cannot be recollected; but No. 10 is 101 cents per pound, the wholesale price; 110 cents the retail price; if the yarn is sold unbleached, 8 cents per pound less is paid for it. No. 36, I think, is $2.60 per pound wholesale; retail, 8 cents per pound more.

19 The most advantage is derived from the true management, of the carding and roving—the cotton is to pass through the breaker and through the card, then through the roving frames according to the number of the yarn which is to be spun. This is in order to draw the harl nicely and evenly together, in the same manner as flax is, by repeatedly drawing over the hackle—if less than No. 6, it commonly passes through but once; if more, it goes through twice or more. Two rovings are commonly put together, which will draw better than more. As many as four are put through sometimes, but it is not so well as two or three; and the two or three are drawn down to the same thickness as one. Numbers from 1 to 5, pass through the roving frames once from 5 to 12; twice, 12 to 20, 3 to 4 times; above 20 to 30, four or five times, seldom or never more than six. In the high numbers the wheels are altered, so that the roving is drawn out finer by putting the driving wheel on the front roller smaller,

and the driver of the back roller larger.

20. The harl of the cotton is not injured in the roving frames by being drawn out, as the rollers are so far apart that the fibres become separated between the rollers and drawn apart.

21. The harl of the cotton is mostly injured in the carding, and which ought to be most nicely attended to : it arises from various causes—the front rollers may be too far apart, and allow the card to feed too fast, and the cotton to go in, in flocks ; the fast cards may be screwed too close.

22. The cards and breakers are both to be occasionally sharpened about every 2 days for the card, and about every week for the breakers; this is done, giving them a reverse motion, and holding before them a board faced with glue and emery : this is to be done very carefully, 15 or 20 minutes is generally enough ; the board is to be held lightly, otherwise by bearing hard, it is apt to leave a quantity of the iron hanging to the end of the teeth and beards them, which is called fish hooking them, and this never comes off, and ruins the card—the fast cards are done by hand. In large factories they use a cylinder covered with emery, and run it round, and thus sharpen the fast cards. The speed in sharpening is about the same, as if the card was at work, say about 75 times a minute. Some of the best cotton spinners do not run the cards more than 65 times a minute, and this it is considered, is better than fast work—above 90 is considered too fast, and breaks the harl.

23 The teeth of the cylinder are about one-sixteenth of an inch from those of the fast card; the cylinder ought to be nicely balanced, otherwise the heavy side is apt to fly off to a greater diameter than the light one, and make bad work—the card leathers to be well attended to, that they are well nailed on, and do not extend in places.

24. When it is required to spin fine yarn, finer than No. 20, stretchers are used to take the yarn from the roving frames, and stretch it before it is spun. The same stretchers on which yarn is spun from No. 1 to 10, are used for stretching from the rovings. Yarn from No. 10 to 20, need not pass through the stretchers. Yarn if ever so fine, is never stretched more than once

25. The difference in construction between the water frames and throstles, is this : In water frames, the motion is communicated from a horizontal drum turned from a small iron shaft, from the main shaft, which drum gives motion to the pulleys and binders : each pulley and each binder turns 4 spindles and threads —thus any 4 may be stopped at once—this is the best mode of spinning and most saving.—It is the most proper when the persons are not fully acquainted with it. The throstles are turned by a long vertical tin drum, which turns about 60 on each side of it; there is no mode of stopping less than the whole at once.

26. 100 spindles in a mule will spin in a day about 30 pounds from No. 8 to No. 10. No. 8 sells for 62½ cents. No. 10 for 68 cents. From No. 10 to No. 20, the quantity may decline—so that No. 20, will be about 10 pounds, and sells for about $1.20.

27. A mule spindle will spin a hank and an half per day, to two hands, according to the goodness of the spinner—and in weight, a pound consists of as many hanks as the numbers are, as 10 hanks of No. 10 are a pound, 20 of No. 20, &c.

28. A throstle spindle about 2½ hanks per day.

29. Water frames about as much as the throstle.

30. The mode the numbers are determined, is by weighing the cotton and spreading it on a certain distance as it goes on the cloth into the breaker; and it is weighed again on its coming off the cylinder of the breaker.

31. I made a calculation at Baltimore, regarding the expence of working a cotton mill, compleat, from beginning to end, and calculate, that business well managed, will afford to turn out cotton at 1½ cents per hank, to include every expence of work people, children, &c. and keep the machinery all in compleat order, except finding oil and candles, for lighting and coal or fuel. This calculation is made for 1000 spindles—the quantity of mules and throstle frames about equal.

32. If the hands become well acquainted with the business, the following hands will be sufficient to conduct it:—Three men. 1 superintendant, 1 for the carding and roving, and 1 for spinning; 5 girls or boys for the spinning ; 12 girls or boys for carding, roving, and drawing, and winding, rovings and reeling.

33. Thomas Wharton, who now resides at Baltimore, and conducts the machinery for W. Levering, has constructed a very excellent machine for spinning flax or tow, and it is from Berbank's invention of Toadhole, near Matlock, Derbyshire.—M'Donald has constructed a loom to go by water.

ESTIMATE.

One carding engine, 24 inches, with workers and stressers	$ 500
One throstle of 144 spindles, at $6 per spindle	864
Two drawing frames, each four heads, with four boss'd rollers	240
One roving, or fly frame, 24 spindles	360
[If cann frames are preferred, they will come at $25 per pair, say 10 pair.]	
One water frame of 120 spindles, at $7 per spindle	840
If you have the throstle and water from the number of spindles above-mentioned, you will require another card, same size as above	500
It is to be observed, that the work will be well executed, and of good materials, for the above prices.	
The number of spindles to be supplied by each card will entirely depend on the number of yarn you are spinning—the calculation which I have given you is for No. 10, or thereabout.	
Mule of 144 spindles, at $3 per spindle	432

Manufacture of Coke. See Coal.

Manufacture of Cutlery. See Cutlery.

Manufacture of German Asses-skin.—Particulars of the Patent granted to Mr. George Cummings, of Ludgate street, London, Toyman; for his Invention of a Composition to put on all sorts of Skins, Paper, or Linen, for drawing or writing on with pen and ink, or pencil, and rubbing clean off again.

The invention consists of a composition to put on all sorts of skins, paper, or linen, for the use of drawing or writing on with pen and ink, or pencil, and rubbing clean off again, and to form it into a memorandum book, distinguished by putting the name of each day of the week on the top of each leaf of the book, and for other uses and purposes, is to be performed in manner following; that is to say, take either vellum, parchment, very fine cloth, or paper, and stretch it in a frame as tight as possible. Then take twelve pounds of white lead, and pound it very fine; add thereto one third part of the best plaister of Paris, and one fourth part of the best stone lime; pound them well, mix them well together, and grind them very fine with water. Then take a new glazed vessel, and dissolve six or seven pounds of the best double size, over a fire, and mix the above ingredients in this, till it is of such a consistence as to lay on with a brush. Then lay three or four layers on the skin or cloth, as smooth as possible; observing that the skin is dry each time, before a second layer is put on. Then take the best nut or linseed oil, and to every pound of this oil add four ounces of the best white varnish, and mix them well together. Then put on three or four layers of this oil, thus prepared, each time exposing it to the air till it is thoroughly dry: this is for the white sort. For a brown or yellow, add to every pound of the above three or four ounces of the best stone oker, or orpiment, or Dutch pink, and three or four ounces of litharge. These must be well ground with very old linseed oil, and laid on, as smooth as possible, ten or twelve times; exposing it each time to the air, to be thoroughly dry, before a second layer is put on: observe you do not put it where any dust or dirt can fall upon it. It may be, by the same process, altered to any colour: as for instance, to a red, by tincturing it with vermilion, or the like; to a blue, Prussian blue; and for a black, by pounding slate, grinding it very fine, and mixing with it as much ivory black as will turn it to a fine black colour. When it is thoroughly dry, you may write on it with a slate pencil, or black or red lead.

Manufacture of Glass. See Glass.

Manufacture of Glue. See Gelatin.

Manufacture of Grained Parchment.—Description of the method employed at Astracan for making grained Parchment or Shagreen. By Professor Pallas.

The process for preparing shagreen is a very old oriental invention, not practised in Europe, and which, as far as we know, has never yet been described; though Basil Valentin is pretty right in what he says of it in general. It is one of those arts of the east, which, like that of the Turkey dye for cotton, the preparation of Russia leather, isinglass, &c. have remained unknown and unemployed, not because they are kept secrets, but because none of the European traveller ever took the trouble to learn them, and because the materials used are not so common and so cheap in Europe. It may be of some

utility, therefore, if we here give a circumstantial description of this art as it is practised at Astracan by the Tartars and Armenians, especially as the method of these people is perfectly similar to that used in Turkey, Persia, and various parts of Bucharia, and as the shagreen-makers of Astracan acknowledge that they obtained the process originally from Persia.

All kinds of horses' or asses' skin, which have been dressed in such a manner as to appear grained, are by the Tartars called *sauwer*, by the Persians *sogre*, and by the Turks *sagri*, from which the Europeans have made *shagreen* or *chagrin*. The Tartars who reside at Astracan, with a few of the Armenians of that city, are the only people in the Russian empire acquainted with the art of making shagreen. Those who follow this occupation not only gain considerable profit by the sale of their production to the Tartars of Cuban, Astracan, and Casan, who ornament with it their Turkey leather boots, slippers, and other articles made of leather; but they derive considerable advantage from the great sale of horses' hides, which have undergone no other process than that of being scraped clean, and of which several thousands are annually exported, at the rate of from seventy-five to eighty-five roubles per hundred, to Persia, where there is a scarcity of such hides, and from which the greater part of the shagreen manufactured in that country is prepared. The hind part only of the hide, however, which is cut out in the form of a crescent about a Russian ell and a half in length across the loins, and a short ell in breadth along the back, can properly be employed for shagreen. The remaining part, as is proved by experience, is improper for that purpose, and is therefore rejected.

The preparation of the skins, after being cut into the above form, is as follows:— They are deposited in a tub filled with pure water, and suffered to remain there for several days, till they are thoroughly soaked, and the hair has dropped off. They are then taken from the tub, one by one, extended on boards placed in an oblique direction against a wall, the corners of them, which reach beyond the edges of the board, being made fast, and the hair with the epidermis is then scraped off with a blunt iron scraper called *urak*. The skins thus cleaned are again put in pure water to soak. When all the skins have undergone this part of the process, they are taken from the water a second time, spread out one after the other as before, and the flesh side is scraped with the same kind of instrument. They are carefully cleaned also on the hair side, so that nothing remains but the pure fibrous tissue, which serves for making parchment, consisting of coats of white medullary fibres, and which has a resemblance to a swine's bladder softened in water.

After this preparation, the workmen take a certain kind of frames called *pälzi*, made of a straight and a semi-circular piece of wood, having nearly the same form as the skins. On these the skins are extended in as smooth and even a manner as possible by means of cords; and during the operation of extending them they are several times besprinkled with water, that no part of them may be dry, and occasion an unequal tension. After they have been all extended on the frames, they are again moistened, and carried into the house, where the frames are deposited close to each other on the floor with the flesh side of the skin next the ground. The upper side is then thickly bestrewed with the black exceedingly smooth and hard seeds of a kind of goose-foot, (*chenopodium album*,) which the Tartars call *alabuta*, and which grows in abundance, to about the height of a man, near the gardens and farms on the south side of the Volga; and that they may make a strong impression on the skins, a piece of felt is spread over them, and the seeds are trod down with the feet, by which means they are deeply imprinted into the soft skins. The frames, without shaking the seeds, are then carried out into the open air, and placed in a reclining position against a wall to dry; the side covered with the seeds being next the wall, in order that it may be sheltered from the sun. In this state the skins must be left several days to dry in the sun, until no appearance of moisture is observed in them; when they are fit to be taken from the frames. When the impressed seeds are beat off from the hair side, it appears full of indentations or inequalities, and has acquired that impression which is to produce the grain of the shagreen, after the skins have been subjected to the last smoothing or scraping, and have been dipped in a ley, which will be mentioned hereafter, before they receive the dye.

The operation of smoothing is performed on an inclined bench or board, which is furnished with an iron hook, and is covered with thick felt or sheep's wool on which the dry skin may gently rest. The skin is suspended in the middle of the bench or board to its iron hook, by means of one of the holes made in the edge of

the skin for extending it in its frame as before mentioned; and a cord, having at its extremity a stone or a weight, is attached to each end of the skin, to keep it in its position while under the hands of the workmen. It is then subjected to the operation of smoothing and scraping by means of two different instruments. The first used for this purpose called by the Tartars *tokar*, is a piece of sharp iron bent like a hook, with which the surface of the shagreen is pretty closely scraped to remove all the projecting inequalities. This operation, on account of the corneous hardness of the dry skin, is attended with some difficulty; and great caution is at the same time required that too much of the impression of the *alabuta* seed be not destroyed, which might be the case if the iron were kept too sharp. As the iron, however, is pretty blunt, which occasions inequalities on the shagreen, this inconvenience must afterwards be remedied by means of a sharp scraping-iron or *urak*, by which the surface acquires a perfect uniformity, and only faint impressions of the *alabuta* seed then remain, and such as the workman wishes. After all these operations, the shagreen is again put into water, partly to make it pliable, and partly to raise the grain. As the seeds occasion indentations in the surface of the skin, the intermediate spaces, by the operations of smoothing and scraping, lose some part of their projecting substance; but the points which have been depressed, and which have lost none of their substance, now swell up above the scraped parts, and thus form the grain of the shagreen. To produce this effect, the skins are left to soak in water for twenty-four hours; after which they are immersed several times in a strong warm ley, obtained, by boiling, from a strong alkaline earth named *schora*, which is found in great abundance in the neighbourhood of Astracan. When the skins have been taken from this ley, they are piled up, while warm, on each other, and suffered to remain in that state several hours; by which means they swell, and become soft. They are then left twenty-four hours in a moderately strong pickle of common salt, which renders them exceedingly white and beautiful, and fit for receiving any colour. The colour most usual for these skins is a sea-green; but old experienced workmen can dye them blue, red, or black, and even make white shagreen.

For the green colour nothing is necessary but filings of copper and sal-ammoniac. Sal-ammoniac is dissolved in water till the water is completely saturated; and the shagreen skins, still moist, after being taken from the pickle, are washed over with the solution on the ungrained flesh side, and when well moistened a thick layer of copper filings is strewed over them: the skins are then folded double, so that the side covered with the filings is innermost. Each skin is then rolled up in a piece of felt; the rolls are all ranged together in proper order, and they are pressed down in an uniform manner by some heavy bodies placed over them, under which they remain twenty-four hours. During that period the solution of sal-ammoniac dissolves a quantity of the cupreous particles sufficient to penetrate the skin and to give it a sea-green colour. If the first application be not sufficient, the process is repeated in the same manner; after which the skins are spread out and dried.

For the blue dye, indigo is used. About two pounds of it, reduced to a fine powder, are put into a kettle; cold water is poured over it, and the mixture is stirred round till the colour begins to be dissolved. Five pounds of pounded *alakar*, which is a kind of barilla or crude soda, prepared by the Armenians and Calmucs, is then dissolved in it, with two pounds of lime and a pound of pure honey, and the whole is kept several days in the sun, and during that time frequently stirred round. The skins intended to be dyed blue must be moistened only in the natrous ley *schora*, but not in the salt brine. When still moist, they are folded up and sewed together at the edge, the flesh side being innermost, and the shagreened hair side outwards; after which they are dipped three times in the remains of an exhausted kettle of the same dye, the superfluous dye being each time expressed; and after this process they are dipped in the fresh dye prepared as above, which must not be expressed. The skins are then hung up in the shade to dry; after which they are cleaned and paired at the edges.

For black shagreen, gall-nuts and vitriol are employed in the following manner:—The skins, moist from the pickle, are thickly bestrewed with finely pulverised gall-nuts. They are then folded together, and laid over each other for twenty-four hours. A new ley, of bitter saline earth or *schora*, is in the mean time prepared, and poured hot into small troughs. In this ley each skin is several times dipped; after which they are again bestrewed with pounded gall-nuts, and placed in heaps for a certain period, that the galls may thoroughly penetrate them, and they are dried and beat, to free them from the

dust of the galls. When this is done, they are rubbed over, on the shagreen side, with melted sheep's tallow, and exposed a little in the sun, that they may imbibe the grease The shagreen-makers are accustomed also to roll up each skin separately, and to press or squeeze it with their hands against some hard substance, in order to promote the absorption of the tallow. The superfluous particles are removed by means of a blunt wooden scraper (*urak*) ; and when this process is finished, and the skins have lain some time, a sufficient quantity of vitriol of iron is dissolved in water, with which the shagreen is moistened on both sides, and by this operation it acquires a beautiful black dye. It is then dressed at the edges, and in other places where there are any blemishes.

To obtain white shagreen, the skins must first be moistened, on the shagreen side, with a strong solution of alum. When the skin has imbibed this liquor, it is daubed over on both sides with a paste made of flour, which is suffered to dry. The paste is then washed off with alum water, and the skin is placed in the sun till it is completely dry. As soon as it is dry, it is gently besmeared with pure melted sheep's tallow, which it is suffered to imbibe in the sun; and, to promote the effect, it is pressed and worked with the hands. The skins are then fastened in succession to the before-mentioned bench, where warm water is poured over them, and the superfluous fat is scraped off with a blunt wooden instrument. In the last operation the warm water is of great service. In this manner shagreen perfectly white is obtained, and nothing remains but to pair the edges and dress it.

But this white shagreen is not intended so much for remaining in that state as for receiving a dark red dye, because, by the above previous process, the colour becomes much more perfect. The skins destined for a red colour must not be immersed first in ley of bitter salt earth, (*schora*,) and then in pickle, but, after they have been whitened, must be left to soak in the pickle for twenty-four hours. The dye is prepared from cochineal, which the Tartars call *kirmitz*. About a pound of the dried herb *tschagann*, which grows in great abundance in the neighbourhood of Astracan, and is a kind of soda-plant orkali, (*salsola ericoides*,) is boiled a full hour in a kettle containing about four common pailfulls of water; by which means the water acquires a greenish colour. The herb is then taken out, and about half a pound of pounded cochineal is put into the kettle, and the liquor is left to boil a full hour, care being taken to stir it that it may not run over. About fifteen or twenty drams of a substance which the dyers call *luter* (orchilla) is added, and when the liquor has been boiled for some time longer the kettle is removed from the fire. The skins taken from the pickle are then placed over each other in troughs, and the dye-liquor is poured over them four different times, and rubbed into them with the hands, that the colour may be equally imbibed and diffused. The liquor each time is expressed; after which they are fit for being dried. Skins prepared in this manner are sold at a much dearer rate than any of the other kinds.

Manufacture of Gun-powder. See Gun-powder.

Manufacture of Hats—Hats are made either of wool, or fur of different animals, particularly of the beaver, rabbit, and camel. The process is nearly the same in all; it will therefore be sufficient if we describe the method made use of in the manufacture of beaver hats.

The skin of the beaver is covered with two kinds of hair, the one long, stiff and glossy; the other is short, thick and soft, and is alone used for hats.

To tear off one of these kinds of hair, and cut the other a large, knife something like a shoe-maker's knife, for the long hair; and a smaller one nearly in the form of a pruning knife, with which they shave or scrape off the shorter hair are used.

When the hair is off, they mix and card it; they then place it on a table having slits in it lengthwise: on this table they mix the hair together, the dust and filth falling through the chinks or slits. In this manner they form gores, as they are called, of an oval shape, and with the stuff that remains they supply and strengthen the parts that may be slighter than they should be. In that part of the brim which is next the crown, the substance is thicker than in the other parts of the hat.

The gores thus finished, the workman goes on to harden them into closer or more consistent flakes by pressure; they are then carried to the bason, which is a sort of bench with an iron plate in it, and a little fire underneath it; upon this gores are laid, sprinkled, and brought into a conical shape by means of a mould.

The hat is now removed to a large receiver or trough, resembling a mill-hopper, to the bottom of which is attached a copper kettle filled with water and grounds, kept hot for the purpose.

The basoned hat is first dipped in the kettle, and then worked for several hours, till it is properly thickened.

The hat is now to receive its due shape; which is done by laying the conical cap on a wooden block of the size of the intended crown, tying it down fast with a piece of packthread at the bottom of the block; after which it is singed, and the coarse nap is taken off, first with a pumice-stone, then with a piece of seal-skin; and lastly, it is carded with a fine card to raise the cotton, with which the hat is afterwards to appear.

When the hat is so far advanced, it is sent, tied with the packthread on its block, to be dyed. This operation is performed by boiling 100 pounds of logwood, 12 pounds of gum, and 6 pounds of gall, in a proper quantity of water; after which 6 pounds of verdigrise, and 10 pounds of green vitriol, are added, and the liquor is kept simmering. Ten or twelve dozen of hats are immediately put in, each on its block, and kept down by cross bars: for about an hour and a half: they are then taken out and aired, and the same number of other hats put in their rooms the two sets of hats are then dipped and aired alternately several times each, the liquor being refreshed each time with more ingredients.

The dye being complete, the hatter hangs it in the roof of a stove or oven, at the bottom of which is a charcoal fire: when dry it is to be stiffened, which is done by melted glue or gum. It is then to be steamed on the steaming-bason, which is a little hearth or fire-place, raised three feet high, with an iron-plate laid over it, on which cloths, moistened with water, are laid, to secure the hat from burning. This operation is done entirely by the hand.

When steamed and dried, it is put again on the block, and brushed and ironed, on a table or bench, called the stall-board, till it receives the gloss which all new hats have. The edges are then clipped very smooth and even, and the lining sewed into the crown.

In Nicholsons Journal, vol 1st, 2d, and 3d, 4to. the art of hat making is fully described.

A patent was granted in January 1782, to Mr. Robert Golding, of Southwark, hat-dyer, for his method of dyeing, staining, and colouring beaver hats green, or any other colour—The inventor directs the nap of the hat to be raised by means of a card, on the side intended to be dyed, and then boiled in alum and argol. A thin paste should be made of flour, or clay, which is spread over every part that is not to be dyed, and then closed; or the hat may be previously pasted, and instead of being boiled, it should be only simmered in the same liquor. As soon as the paste is spread, plates of copper or other metal, shaped like a common funnel, are fixed over the paste, to prevent the dye from penetrating through. In this state, the hat is immersed in the dye, till the colour be sufficiently fixed; when it is taken out, opened, and cleansed from the paste: but, if any colouring particles have penetrated through the felt, they may be removed by rubbing them with a small quantity of spirit of salt, aqua fortis, &c. The compounds employed in dyeing, are fustic, turmeric, ebony, saffron, alum, argol, indigo, and vitriol, with urine, or pearl-ash, at the option of the dyer; all of which are used together, or separately, according to the colour required.

Among the different patents granted to hatters, for discovering new materials in this manufacture, such as that of Mr. J. Burn, in 1792, for mole-fur; and another to Mr. J. Tilstone, in 1794, for kid-hair; we shall only notice an invention of Mr. George Dunnage, who, in November 1794, obtained a patent for his Water-proof Hats, in imitation of beaver.

The articles he employs are similar to those commonly used for the making of hats, with which he mixes Bergam, Piedmont, or Organzine silk. These are dressed and worked in a peculiar manner; though we understand that hats thus prepared become heavy and oppressive to the wearer, while they acquire an ugly colour—The curious reader will find the patentee's specification inserted, at full length, in the 4th vol. of the Repertory of Arts and Manufactures. The same manufacturer procured another patent in November 1798, for a method of ventilating the crowns of hats. This invention consists in separating the top from the sides of the crown, so that the tip, or top crown, may be either raised or let down at pleasure, in order to admit the external air, or to exclude it from circulating in the crown of the hat. The whole contrivance is effected by means of springs, sliders, sockets, grooves, loops, and cases, which are connected with the top and side-crown: thus the admission or exclusion of atmospheric air in front, behind, or on either side, may be regulated accordingly—As this invention is ingenious, we refer the reader to the 10th vol. of the work last quoted, where he will find a minute account, illustrated by an engraving.

In November, 1801, a patent was obtained by Messrs. John Walker and Peter Alphey, for contriving water-proof hats and caps, as likewise for rendering silk, linen, leather, cotton, and other materials for wearing apparel, water-proof—Their invention consists in providing the respective articles with a coat of oil-paint; after which they are japanned with a varnish mixed with lamp or ivory-black. The caps and hats are manufactured of paste-board covered with canvas, and treated in a similar manner; but the leather, to be made water-proof, should not be previously dressed with oil, or any unctuous matter—For a more minute account of the method in which the different compositions are applied, the reader will consult the 16th vol. of the "Repertory of Arts," &c.

Manufacture of Indigo. See Indigo.

Manufacture of Ink. See Ink.

Manufacture of Isinglass. See Gelatin.

Manufacture of Lakes. See Lakes and Colour-Making.

Manufacture of Lead, or Plumbing—The business of the plumber consists in the art of casting and working of lead, and using it in buildings. He furnishes us with a cistern for water, and with a sink for the kitchen; he covers the house with lead, and makes the gutters to carry away the rain-water; he makes pipes of all sorts and sizes, and sometimes he casts leaden statues as ornaments for the garden. The plumber also is employed in making coffins for those who are to be interred out of the common way. And besides these departments in his trade, the modern plumber makes no small share of his profits by laying pipes and introducing water into our houses. Of these there are many different kinds, and but few inventions in modern days have answered so well as these.

The chief articles in plumbery consisting in sheets and pipes of lead we shall briefly describe the processes of making them.

In casting sheet-lead, a sort of table, or mould, is used, about four or five feet wide, and sixteen or eighteen feet long; it must slope a little from the end in which the metal is poured on, and the slope must be greater in proportion to the thinness of the lead wanted. The mould is spread over with moistened sand about two inches thick, and made perfectly smooth by means of a piece of wood called a *strike*. At the upper end of the mould is a pan of a triangular shape. The lead, being melted, is put, by means of ladles, into this pan; and when it is cool enough, two men take the pan by the handle, (or else one of them lifts it by a bar and chain fixed to the beam in the cieling,) and pour it into the mould, while another man stands ready with the *strike* to sweep the lead forward, and draw the overplus into a trough ready to receive it. The sheets being thus cast, it remains only to roll them up or cut them to any particular size.

If a cistern is wanted, they measure out the four sides, and form any figures intended to be raised on the front in the sand, and cast as before; the sides are then soldered together, after which the bottom is soldered in.

Pipes are cast in a kind of mill, with arms or levers to turn it. The moulds are of hollow brass, consisting of two pieces, about two feet and a half long, which open and shut by means of hinges and hooks. In the middle of these moulds is placed a core or round solid piece of brass or iron, somewhat longer than the mould. This core is passed through two copper rundles, one at each end of the mould, which they serve to close; to these is joined a little copper tube two inches long, and of the thickness of the intended leaden pipe. These tubes retain the core exactly in the middle of the cavity of the mould, and then the lead is poured in through an aperture in the shape of a funnel. When the mould is full, a hook is put into the core, and, turning the mill, it is drawn out, and the pipe is made. If it is to be lengthened, they put one end of it in the lower end of the mould, and the end of the core into it, then shut the mould again, and apply its rundle and tube as before, the pipe just cast serving for a rundle, &c. at the other end. Metal is again poured in which unites with the other pipe, and so the operation is repeated till the pipe is of the length required.

Large pipes of sheet-lead are made by wrapping the lead on wooden cylinders of the proper length, and then soldering it up the edges. See Lead.

Manufacture of Leather. See Leather.

Manufacture of Marine Acid. See Muriatic Acid.

Manufacture of Morocco Leather. See Leather.

Manufacture of Oil of Vitriol. See Sulphuric Acid.

Manufacture of Paints. See Colours.

Manufacture of Paper See Paper.

Manufacture of Paper Hangings. See Paper.

Manufacture of Parchment. See Parchment.

Manufacture of Pewter. See Tin.

Manufacsure of Pins and Needles.—There is scarcely any commodity cheaper than pins, and but few that pass through more hands before they come to be sold. It is reckoned that twenty-five workmen are successively employed in each pin, between the drawing of the brass wire and the sticking of the pin in the paper.

It is not easy to trace the invention of this very useful little implement; it is first noticed in the English statute book in the year 1483, prohibiting foreign manufactures: and it appears from the manner in which pins are described in the reign of the British king Henry the VIIIth, and the labour and time which the manufacture of them would require, that they were a new invention in England, and probably brought from France.

At this period pins were considered in Paris as articles of luxury; and no master pin-maker was allowed to open more than one shop for the sale of his wares, except on New-year's day, and the day before that: it should seem, therefore, that pins were given away as New-year's gifts; hence arose the phrase pin-money, the name of an allowance frequently made by the husband to his wife for her own spending.

Pins are now made wholly of brass wire; formerly iron wire was made use of, but the ill effects of iron have nearly discarded that substance from the pin-manufactory. The excellence and perfection of pins consist in the stiffness of the wire, and its blanching; in the heads being well turned, and the points accurately filed. The following are some of the principal operations.

When the brass wire, of which the pins are formed, is first received, it is generally too thick for the purpose of being cut into pins. It is therefore wound off from one wheel to another, with great velocity, and made to pass between the two, through a circle in a piece of iron of smaller diameter. The wire is then straightened, and afterwards cut into lengths of three or four yards, and then into smaller ones, every length being sufficient to make six pins; each end of these is ground to a point, which is performed by a boy, who sets with two small grinding-stones before him, turned by a wheel. Taking up a handful, he applies the ends to the coarsest of the two stones, being careful at the same time to keep each piece moving round between his fingers, so that the points may not become flat: he then gives them to the other stone; and by that means a lad of twelve or fourteen years of age is enabled to point about 16,000 pins in an hour. When the wire is thus pointed, a pin is taken off from each end, and this is repeated till it is cut into six pieces. The next operation is that of forming the heads, or, as they term it, *head spinning;* which is done by means of a spinning-wheel, one piece of wire being thus, with astonishing rapidity, wound round another, and the interior one being drawn out, leaves a hollow tube; it is then cut with shears, every two turns of the wire forming one head; these are softened by throwing them into iron pans, and placing them in a furnace till they are red-hot. As soon as they are cool, they are distributed to children, who sit with their anvils and hammers before them, which they work with their feet, by means of a lathe; and taking up one of the lengths, they thrust the blunt end into a quantity of the heads that lie before them, and catching one at the extremity, they apply them immediately to the anvil and hammer, and by a motion or two of the foot, the point and the head are fixed together in much less time than it can be described in, and with a dexterity only to be acquired by practice, the spectator being in continual apprehension for the safety of their fingers' ends.

The pin is now finished as to its form, but still it is merely brass; for which purpose it is thrown into a copper containing a solution of tin and the leys of wine. Here it remains for some time; and when taken out it assumes a white though dull appearance. To give it a polish, it is put into a tub containing a quantity of bran, which is set in motion by turning a shaft that runs through its centre, and thus by means of friction it becomes perfectly bright. The pin being complete, nothing remains but to separate it from the bran, which is performed by a mode exactly similar to the winnowing of corn, the bran flying off, and leaving the pin behind fit for immediate sale.

The pins most esteemed in commerce are those of England; those of Bordeaux are next; then those made in some of the other departments of France. The London pointing and blanching are most in repute, because they, in pointing, use two steel mills, the first of which forms the point, and the latter takes off all irregularities, and renders it smooth, and, as it were, polished; and in blanching they use block-tin, granulated; whereas, in other places they mix their tin with lead and quicksilver, which not only blanches worse than the former, but is also dangerous, as any puncture made with pins of this sort is not so readily cured.

Pins are distinguished by numbers; the smaller are called from No 3, 4, 5, to the 14th, whence they go by *two's*, No. 16, 18, and 20, which is the largest size. Besides the white pins, there are black ones, made for the use of mourning, from No. 4 to No 10. Pins are also distinguished by weight, as 4 lb. pins, 4½ lb. pins, 5 lb. pins—meaning 4 lb. to the thousand—4½ lb. to the thousand—5 lb. to the thousand There are pins with double heads of several numbers, used by ladies to fix the buckles of their hair for the night, without the danger of pricking.

The tinning of brass pins may be performed by boiling them between plates of sheet tin, or tin plate, in a solution of cream of tartar. A manufactory of pins has been established at Boston. During the Revolution, they were made in Philadelphia.

We shall now give a short account of the manufacture of needles: these make a very considerable article in commerce: the consumption of them is almost incredible. The sizes are from No. 1, the largest, to No. 25, the smallest. In the manufacture of needles, the German and Hungarian steel are in the most repute.

The first thing in making needles is, to pass the steel through a coal fire, and by means of a hammer to bring it into a cylindrical form. This being done, it is drawn through a large hole of a wire-drawing iron, and returned into the fire, and drawn through a second hole of the iron smaller than the first, and so on till it has acquired the degree of fineness required for that species of needles. The steel, thus reduced to a fine wire, is cut in pieces of the length of the needles intended. These pieces are flatted at one end on the anvil, in order to form the head and eye. They are then softened and pierced at each extreme of the flat part, on the anvil, by a punch of well-tempered steel, and laid on a leaden block to bring out, with another punch, the little piece of steel remaining in the eye. When the head and eye are finished, the point is formed with a file, and the whole filed over: they are then laid to heat red hot on a long narrow iron, crooked at one end, in a charcoal fire; and when taken out thence, they are thrown into a bason of cold water to harden. They are then laid in an iron shovel on a fire more or less brisk in proportion to the thickness of the needles, taking care to move them from time to time This serves to temper them, and take off their brittleness. They are now to be straightened, one after another, with the hammer.

The next process is the polishing. To do this they take twelve or fifteen thousand needles, and range them in little heaps against each other on a piece of new buckram sprinkled with emery-dust. The needles being thus disposed, emery-dust is thrown over them, which is again sprinkled with oil of olives; at last the whole is made up into a roll, well bound at both ends. This roll is laid on a polishing-table, and over it a thick plank loaded with stones, which men work backwards and forwards for two days successively: by these means the needles become insensibly polished. They are now taken out, and the filth washed off with hot water and soap: they are then wiped in hot bran, a little moistened, placed with the needles in a round box, suspended in the air by a cord, which is kept stirring till the bran and needles are dry. The needles are now sorted; the points are turned the same way, and smoothed with an emery stone turned with a wheel; this is the end of the process, and nothing remains to be done but to make them up in packets of 250 each.

Needles were first made in England, by a native of India, in 1545, but the art was lost at his death: it was, however, shortly after recovered by Christopher Greening, who, with his three children, were settled by Mr. Damer, ancestor of the present Lord Milton, at Long Crendon, in Bucks, where the manufactory has been carried on from that time to the present.

In order to preserve needles from rust, they may be sprinkled with whiting, or if rusted, may be passed through a small bag containing powdered emery.

Manufacture of Saws.—Mr. Arnold Wilde, and Mr Joseph Ridge, of Great Britain, have obtained a patent for making and manufacturing different kinds of saws, &c.

This invention is described as follows: —Our said invention of making and manufacturing all kinds of saws, steel doctors for printers, plates made of iron, also of steel, beads, mouldings, and fender plates made of iron and steel united, or of iron or steel, and all sorts of springs made of steel, and divers other articles made of iron and steel united, and also of iron or steel, is particularly described and ascertained in manner following; that is to say: When the steel or iron is pared or cut into proper shape, the saws, doctors for printers, plates of iron or steel, beads, mouldings, and fender plates, whether made of iron and steel united, or of iron or steel, and all sorts of springs made of steel, and divers other articles made of iron and steel united, and also of iron or steel, are

put into a frame of metal, or otherwise: they may then be made red-hot in the said frame, and stretched by screw, spring, weight, or any other proper power or purchase, and so formed into a curved, straight, or any other direction wanted. They are then to be immersed in water, or a composition of oils or grease, to be hardened in the frame in the direction wanted; and when so hardened they are also to be tempered in the same direction in the frame over fire: and when the saw, doctor for printers, or plate, is over the fire, it must be kept in motion until the oil or grease upon the said saw, doctor, or plate, smokes. It is then to be gently stretched, and continually kept moving over the fire until a blue blaze alternately appears and disappears. It is then to be stretched with as much power as will bring it into the direction required. The saw, doctor, or plate, is next to be put into another frame, which may be made to move upwards and downwards, or in any other direction necessary, by crank, or any other movement, between proper stones, or between plates of metal, blocks of wood, or any other material that will grind or polish with sand, emery, or other proper material to grind and polish the saws, steel doctors for printers, plates made of iron, also of steel, heads, mouldings, and fender plates, made of iron and steel united, or of iron or steel, and all sorts of springs made of steel, and divers other articles made of iron and steel united, and also of iron or steel. But if the saw, doctor, or plate, is not intended to be hardened, it must be made red hot, and stretched with as much power as will bring it into the direction wanted; it must then lie in the open air, in the frame, in the said direction required, till cold: then to be ground by a machine for the purpose of grinding and polishing in a frame the said saws, steel doctors for printers, plates made of iron, also of steel, beads, mouldings, and fender plates, made of iron and steel united, or of iron or steel, and all sorts of springs made of steel, and divers other articles made of iron and steel united, and also of said saw, doctor, or plate, by means of a crank, or otherwise, as before expressed.

Manufacture of Malt.—In addition to the remarks heretofore made, on the preparation of malt, we have given the following as a sketch of the improved kiln, invented by Mr. Barrett.

Air tubes are fixed in such a manner that the air, heated by passing round the neck of the kiln, can be made either to pass out above or below the malt at pleasure: this contrivance, Mr. Barrett says, effectually carries off the great quantity of steam which is generated in drying the malt; and is particularly serviceable in the process of drying pale malt: the extremities of the above passages are closed with iron lattice to hinder vermin from entering.

To prevent the absorption of heat, the walls of the kiln are built hollow, or with hollow passages in them, at every side; the floor of the ash-pit, and the whole area on which the kiln stands, is laid on arches for the same purpose.

The regulator for closing the upper part of the kiln consists of four sheet iron quadrants, which turning on pivots in the line of the middle radius of each, in such manner, that when in a horizontal position, they form a completely close disk, which stops the whole of the aperture, and when in a vertical position they leave it entirely open; in all intermediate positions, they leave a passage for the heated air to pass out proportionate to their degree of inclination, and, when so placed, resemble much the fliers of a smoke-jack; a wire passes from each quadrant a little way down and hooks to another wire or chain, common to all four, which passes down to the front of the fire-place, and by pulling which the workmen can close the upper aperture to any degree he chooses; it may be easily conceived how, on letting go the wire, the quadrants could be contrived to open, by having weights so fixed to them, as to make them preponderate at one side of their centres of motion.

This regulator will at once extinguish all accidental fires in the kiln; will economize heat in preventing the access of cold air downwards on the malt when the drying first commences (which will be particularly useful in drying pale malt) and, by being closed when the kiln is not in use, will protect the kiln-wire, or hair cloth, from damage by the weather, or soil from birds.

The moveable furnace is of an oblong shape, and is constructed with a fire-chamber, and ash-pit, with doors and registers in the same manner as a chymical furnace; there is a damper annexed to it, so contrived that, by moving it to a certain degree, a new passage is opened for the fire into the iron flue next to be described, and the direct passage to the malt closed.

The use of this iron flue (which forms the fourth principal contrivance) is to permit the burning of common coal for heating the kiln, when culm or coke cannot easily be had. It consists of a flue of cast-iron, through which the smoke passes into a chimney, around which another tube

is made to pass spirally, one extremity of which communicates with the space beneath the frame for sustaining the malt, and the other is connected with pipes passing through the body of the fire (or where they will receive considerable heat from it) to the external air. By this means the air is heated so, in circulating round the iron flue, as to dry the malt effectually, and at the same time be totally separated from the smoke.

Mr. Barrett recommends the use of iron in the formation of the cowl, of the internal doors, and of the window frames, as being not liable to warp or shrink, and free from danger of burning.

Besides these contrivances, Mr. Barrett mentions two doors of iron or earthen ware, moveable at pleasure, placed at each side at the further end of the neck of the kiln, to equalize the flame arising from wood, in drying brown malt, which seems to be particularly useful: as Mr. Barrett says this object cannot be obtained by any skill or labour of the workmen, in kilns of the old construction, but of which he has unfortunately given no accurate description either as to their size, position, or management.

Manufacture of Shagreen. See Leather.

Manufacture of Shot. See Lead.

Manufacture of Soap. See Soap.

Manufacture of Spirits. See Spirit, Alcohol, &c.

Manufacture of Starch. See Starch.

Manufacture of Steel. See Iron.

Manufacture of Sugar. See Sugar.

Manufacture of Tin-plate. See Iron.

Manufacture of Verdigrease. See Copper.

Manufacture of Vinegar. See Vinegar.

Manufacture of Wine. See Wine.

Manufacture of Wire.—The manufacture of wire of iron, silver, gold, brass, &c. for different purposes, has been carried on to some extent in the United States.

Metal wires are frequently drawn so fine as to be wrought with other threads, of silk, wool, or hemp; and thus they become a considerable article in the manufactures. The metals most commonly drawn into wire are gold, silver, copper, and iron.

Silver wire and gold wire are manufactured in the same manner, except that the latter is covered with gold. There are also counterfeit gold and silver wires, made of copper gilt and silvered over.

The business of a wire-drawer is thus performed: if it is gold wire that is wanted, an ingot of silver is double gilt, and then by the assistance of a mill it is drawn into wire. The mill consists of a steel plate, perforated with holes of different dimensions, and a wheel which turns the spindles. The ingot, which at first is but small, is passed through the largest hole, and then through one a degree smaller, and so continued till it is drawn to the required fineness; and it is all equally gilt, if drawn out as fine as a hair.

The next operation is that of the flatting mill, which consists of two perfectly round and exquisitely polished rollers, formed internally of iron, and welded over with a plate of refined steel; these rollers are placed with their axes parallel and their circumferences nearly in contact; they are both turned with one handle; the lowermost is about ten inches in diameter, the upper about two, and they are something more than an inch in thickness. The wire unwinding from a bobbin, and passing between the leaves of a book gently pressed, and through a narrow slit in an upright piece of wood, called a ketch, is directed by a small conical hole in a piece of iron, called a guide, to any particular part of the width of the rollers, some of which are capable of receiving, by this contrivance, forty threads. When the wire is flatted between the rollers, it is wound again on a bobbin, which is turned by a wheel, fixed on the axis of one of the rollers, and so proportioned, that the motion of the bobbin just keeps pace with that of the rollers.

Brass and copper wire is drawn in a similar manner to that already described. Of the brass wire there are many different sizes, suited to different kinds of works. The finest is used for the strings of musical instruments. Pin-makers also use great quantities of wires of several sizes to make pins of.

Iron wire is made from bars of iron, which are first drawn out to a greater length, to about the thickness of half an inch in diameter, at a furnace with a hammer gently moved by water. These thinner pieces are bored round, and put into a furnace to anneal. A very strong fire is necessary for this operation.

They are then delivered to the workmen called rippers, who draw them into wire through two or three holes, and then they are annealed a second time; after which they are to be drawn into wire of the thickness of a pack thread: after this they are again to be annealed, and then delivered to the small-wire-drawers. The plate, in which the holes are, is iron on the outside and steel on the inside surface, and the wire is anointed with oil, to make it run the easier. The first iron that runs from the

ore, when melting, being the softest and toughest, is usually preserved to make wire of.

It is difficult to determine the period when attempts were first made to draw into threads metal cut or beat into small slips, by forcing them through holes in a steel plate. It should appear that as long as the work was performed by the hammer, the artists at Nuremberg were called wire-smiths; but after the invention of drawing iron, they were denominated wire-drawers, or wire-millers. Both these appellations occur in history so early as the year 1351; therefore the invention must have been known in the fourteenth century.

At first, threads exceedingly massy were employed for weaving and embroidery: it is not at all known when the flatted metal wire began to be spun round linen or silk thread. The spinning-mill, by which the labour is now performed, is a contrivance of great ingenuity.

The wire first spun about thread was round; and the invention of previously making the wire flat is probably a new epoch in the history of the art: and it is a curious fact, that three times as much silk can be covered by flatted as by round wire; so that various ornamental articles are cheap in the same proportion. Besides, the brightness of the metal is heightened in an uncommon degree, and the article becomes much more beautiful.

The greatest improvement ever made in this art, was undoubtedly the invention of the large drawing-machine, which is driven by water, or by steam, and in which the axle-tree, by means of a lever, moves a pair of pincers, that open as they fall against the drawing-plate; lay hold of the wire, which is guided through a hole of the plate; shut as they are drawn back; and in that manner pull the wire along with them.

The following extract from the memoir of Messrs. Mouchel, of l'Aigle, in the department de l'Orne, on the manufacture of iron and steel wire, may be interesting.

This is one of the most considerable manufactories of this kind in France, and is said to produce a hundred thousand quintals of iron wire annually, in cards for wool-combing only.

When the iron has been formed into an irregular bar of about a centimetre (.39371 inches English) in diameter, they begin to draw it into wire. For this purpose they first pass it four times through the drawing plate. The fibres which appear at the utmost extension of the molecules that are arranged lengthways, are removed by heat, and the process again repeated three times. The whole operation is thus repeated five times, and consequently the wire is passed through fifteen numbers; after which a single heating is sufficient to fit it to pass through six others, and then it is reduced to the thickness of a knitting needle. Steel wire being much harder than that made of iron, requires to be passed through forty-four numbers, and to be annealed every second time. The wire is drawn with either the pincers or the bobbin, which is a cylinder adapted to axle-trees. This last was invented by the grandfather of Messrs. Mouchel, and is used to prevent the marks occasioned by the application of the pincers. The degree of heat required in annealing the wire must be regulated by the diameter; as upon this much of the perfection of the manufacture depends. When the wire is sufficiently stretched at each heating, it assumes a peculiar colour, which the workmen are careful to observe.

For annealing the wire, these manufacturers employ a large elevated furnace, in which the wire is supported in the middle of the flames on bars of cast iron. This furnace is capable of containing seven thousand pounds weight of wire, so arranged, that the thickest is exposed to the greatest heat; so that the whole becomes equally heated in the same time. An inconvenience, however, is experienced with this furnace, which leaves the heated wire exposed to the atmospheric air, which occasions both a considerable loss of oxyd, and an expense in removing it. In order to prevent this, they have invented another furnace, which is round, and about one metre six decimetres (near 5 feet 3 inches English) in diameter; and one metre eight decimetres (5 feet 10.8678 inches) in height, exclusive of its parabolic arch and chimney. The interior of this furnace is divided into three parts; the first receives the cinders; the second is the fire place; and the third receives the wire, which is placed between two cylinders, situated within each other, and made air tight. The diameter of the larger cylinder is about one metre four centimetres (near 55 inches) and that of the inner one about one metre (39.371 inches;) and the fire circulates about the exterior surface of the former, and within the latter. Several pairs of cylinders are provided, in order that they may be changed every hour, which is effected by means of a lever, that enables one man to draw them out or push them in at pleasure. These cylinders are not opened till some time after they are drawn out of the fire, which

prevents the oxidation that would take place if the atmospheric air was admitted while the wire was hot. This new furnace is more expensive than that which was previously used; but its advantages more than counterbalance this expense. It is used for all wire intended for cards; and the large furnace for that of a larger and harder kind; but in order to diminish the formation of the oxyd, the bundles of wire are dipped into a quantity of wet clay, and then put into the furnace, and suffered to dry before the fire is lighted.

These authors make use of two sorts of drawing plates; large and small; in the formation of which great care is necessary, as much depends upon the ability with which this is executed. The method they employ for this purpose is to put pieces of iron of a proper size and quality, into a furnace with cast steel, and increase the heat until the latter is fused; then the iron is taken out, and the steel that adheres to it is amalgamated with it by gentle blows.

It is then permitted to cool, and the same process repeated several times, till the plate has acquired its proper form and hardness. It is necessary that these plates should be of considerable thickness; and the smallest used by Messrs. Mouchel are at least two centimetres (.78742 inches) in thickness. After the wire has undergone the last operation in the workshop of the wire drawer, and is reduced to the required degree of fineness, the smallest of which is stated at 100,000 metres in length to a chiliogram; or $109,366\frac{2}{3}$ yards to 2lb. 3oz. 5dr. avoirdupois, by means of the bobbin, it is subjected to the process of dressage or straightening, which is esteemed the most difficult and delicate of all the operations. By this it loses the bend or curve it had acquired on the bobbins. For the more readily and effectually performing this part of the manufacture, these authors have also invented apparatus for both straightening the wire, and determining its suppleness. But for a particular description of these, with other particulars, and a table of the prices of the different sorts and sizes of wire, we must refer to the Numbers of the Repertory of Arts.

Those persons who are either engaged or interested in manufactures of this nature, we conceive would be amply repaid for their trouble of perusing this memoir. It will be found to combine a much greater degree of scientific ingenuity and practical experience than are usually met with in similar essays, and the success with which these have been exerted may easily be inferred from the fineness of the wire produced. From the above statement it appears that a pound avoirdupois of the smallest wire contains about 49,553 yards in length. Now, admitting the specific gravity of this wire to be 7788, and a pound will contain $\frac{2304}{649}$ cubic inches. Therefore $\frac{2304}{649} \times \frac{1}{49553 \times 36}$ $= \frac{64}{32159897} = .00000199316$ inches for the area of its section, and consequently, .0091593 for its diameter.

Another circumstance which confirms our opinion relative to the formation of the drawing plates, is, that one of these large plates reduces 1400 chiliograms, from the largest size to that of No. 6, which is about the thickness of a knitting needle; and 400 chiliograms are also reduced from this size to the smallest carding wire, by being passed twelve times successively through a single small plate. This we apprehend could not take place, unless they were very perfect.

MANURE. See Agriculture.

MANUSCRIPT, copying of.—This process, communicated to the Philosophic Society at Paris by Charles Caquebent, is the more interesting as it requires neither machine nor preparation, and may be used in any situation. It consists in putting a little sugar in common writing ink, and with this the writing is made on common paper sized as usual. When a copy is required, unsized paper is taken and lightly moistened with a sponge. The wet paper is then applied to the writing, and a flat iron, such as is used by a laundress, of a moderate heat, being lightly passed over the unsized paper, the counter proof or copy is immediately produced. That sugar prevents ink from speedily drying has long been known, and this method of impression has been used in many public offices at an immense saving of trouble and labour.

MANUSCRIPTS, to revive old, when defaced.—Let the obliterated paper be slightly moistened with a sponge dipt in cold water, after which some galls finely levigated, are to be sifted over the paper. When it is perfectly dry, the powder should be gently shaken off, or removed with a soft brush: thus, part of it will adhere to the former outlines that still exist in the paper, and the letters will immediately re-appear.

MAPLE SUGAR.—Under this article we shall consider the mode of manufacturing sugar from the maple tree (*acer*-

saccharum of L.) as practised in different parts of the United States, especially in the western counties of all the middle states. The directions given in this article for manufacturing maple sugar are extracted from a pamphlet published in this city in 1790 Dr. Rush, in the third volume of the Amer Phil. Trans. has given an excellent paper on the sugar maple tree. The importance of this tree to the United States, is daily exemplified from the immense quantity of sugar now made. It is said that four men will turn out in from four to six weeks, 40 cwt. of good sugar. The following calculation of utensils is made for four men.

Detail and description of the necessary utensils and materials.

Kettles.—Sixteen, of about fifteen gallons each.

Iron Ladles.—Two, the bowls to contain three or four quarts each, for shifting the syrup: the handles to have sockets, which may be extended with wood to any convenient length.

Trammels or Pot-Racks.—Sixteen, one for each kettle, the flat part, eighteen inches long; and the round or lower piece, the same; so as to lengthen to about three feet, occasionally.

Screw Augers.—Four, of an half, three quarters, and one inch, for boring the trees. Chopping notches into the tree from year to year, should be forborne; an auger hole answers the purpose of drawing off the sap, equally well, and is no injury to the tree.

Buckets.—Eight or ten, of three gallons each, at least, for collecting the sap.

Boards.—Eight or ten, round pieces, to lay on the surface of the sap, at the top of the buckets, to prevent its splashing over.

Coolers.—Three or four tubs, of about fifteen gallons each (kettles will answer the purpose, to receive the syrup from the boilers, when, upon trial from the proof stick, it draws into a thread between the thumb and finger, as hereafter described.

Yokes.—Four, to go across the shoulders of the persons employed in collecting the sap, having a bucket suspended at each end.

Troughs.—Eight hundred should be made of white pine, white ash, water ash, aspen, linden or bass-wood, poplar, common-maple or sugar-maple: *avoid for this use, the butter-nut,* [*juglans alba* (*oblonga*,)] *chesnut and oak*; these would either discolour the sap, or give it an improper taste. A person acquainted with this business, can cut down the timber proper for the purpose, and hollow out about twenty of these troughs in a day; they generally hold from two to three gallons: the largest should be placed to receive the sap of those trees that are most thriving, and which yield the greatest quantity. It may also be noted, that white-ash and white-pine will make the troughs when green; the other kinds of timber, above-mentioned, should be seasoned, or they will be liable to leak.

Store Troughs.—Where large cisterns, fit for the purpose, cannot be had, which will generally be the case in a new country, troughs may be made of the white-pine, by felling a large tree of that kind, and fixing it in a level position; the upper side to be dug out in the shape of a manger for feeding cattle: the larger it can be made for receiving the green sap, the better. White-ash and linden or brass-wood, will also answer the purpose; should any of them split and leak, they may be caulked tight. These troughs should be at a convenient distance from the boilers, in a cool place, and under cover, to prevent snow, rain, &c. mixing with the sap. A linen strainer should be so fixed that the sap, when collected in buckets, may pass through such strainer into these troughs, at one end; and, at the other end, room should be left to dip out for feeding the boilers.

Sheds, Walls, &c.—The exposed manner in which sugar has been usually made, in the back country, is attended with many inconveniences, especially in windy weather, when the ashes, leaves, &c. may be blown into the boilers, and thereby discolour the syrup, or injure its flavour; neither can the keeping up a proper degree of heat be always effected in an exposed situation To remedy these inconveniences it is recommended that a back wall, for the fire-place, be erected, eighteen or twenty inches high, and to extend a sufficient length for all the boilers employed. This wall may be made of stones laid in clay or loam, where lime-mortar is not readily to be had. For saving the ashes, and the greater convenience in making and continuing a regular fire, under the boilers, a hearth of flat stone, about three feet wide, should be made, to extend an equal length with the back wall. And further to obviate the bad effects, which too open an exposure is subject to, it being observed where a number of boilers are placed in a range, those at, and near, the outer ends, do not succeed so well as the more central ones, it is strongly recommended that sheds be erected, to extend over and cover the whole length of the hearth; and so formed that the smoke may pass off, and be at

the same time a shelter from high winds, rain, snow, &c. For graining the syrup, after it is brought to a proper state in the boilers, it will be right to have a separate shed or building, in which two of the sixteen kettles should be fixed; for this service, charcoal is much better than wood, as the heat or flame should be confined to the bottoms of the kettles; and be uniform and regular, to guard against burning or scorching. A wall, as above described, should be made at the back of the fire-place, as well as at each end; and the hearth or bottom laid with flat stones, on which charcoal is to be placed.

Andirons.—Pieces of cast-iron, something like andirons, and to serve the same purpose, will be very useful: they should, in the long part, be two feet and an half, and two inches square; the turn at the inner end, four inches downwards, and a small turn upwards, at the outer end, of about two inches, to prevent the wood from rolling. Of these, there should be a number to suit the extent of the fire-place, to be placed at the distance of five or six feet from each other.

Sugar-Moulds.—These should be made of seasoned boards, or of such wood as will not impart a taste to the sugar, and somewhat resembling a mill-hopper, about twenty-seven inches long, and ten or twelve inches wide, at the top, and tapered to the width of one inch, at the lower end.

Frames, to place the moulds in, above described, should be formed so as to admit the moulds to rest in them, about half their depth.

Gutters, spouts, or narrow troughs, should be fixed within the frames, under the moulds, in a descending position; the lower ends to enter covered casks or vessels, so that when the plugs or stoppers are drawn from the bottom of the moulds, which may be done, in about twenty-four hours after they are set, the molasses that will run therefrom, may fall into these gutters, and pass readily into the covered vessels, which, if open, would be exposed to dust and dirt.

Prickers.—So termed by the sugar-bakers, about twelve inches long and a half an inch diameter, at one end, and the other, brought to a point; for want of iron, they may be made of hard wood; a few hours after the moulds are unstopped, the prickers should be run up to the bottom of them, three or four inches, to make way for the whole quantity of molasses to pass off.

Process or mode of manufacturing the sap of maple, which by further experience and close observation may, probably, hereafter, admit of considerable improvement.

Seasons for Tapping.—By trials, made in the month of February, it will readily be discovered, when this valuable tree ought to be bored, for the purpose of extracting the sap, as in that month, either earlier or later, according to the season, it generally begins to yield a sufficient quantity for commencing the business.

Tapping or Boring.—Four hundred trees, each bored with two holes, as nearly as may be on the south side; and also with two holes on the north side of the tree, in the early part of the season, with screw augers from two to four quarters of an inch, according to the size of the tree; and toward the middle of the season, a like number of trees to be bored in the same manner, is recommended, as a better mode for the management of four hands, than if the whole number of eight hundred trees were tapped at the first running of the sap. The sap of the second parcel tapped, will be found richer, and more productive, than if a part had been extracted earlier. The auger should enter the tree, at first, not more than three quarters of an inch: the holes may, at several times, be deepened to the extent of two inches and an half, as the manner of the sap's running may render necessary. The hole should be made slanting or descending, so that the sap may run freely in frosty weather, and not, by a slow motion, be liable to freeze in the mouth of the orifice. In these holes, spouts should be fixed, to project from the tree, from eight to twelve inches, and not to enter the tree more than about half an inch; as the farther they enter, the more the running of the sap is obstructed: they should be prepared, in readiness for the season, of elder or sumach.

Preserving the Sap.—In the early part of the season, the sap will keep two or three days without injury; but as the spring advances, it will be necessary to boil the sap the day after it is collected, or it may ferment and sour.

Lime.—To every half barrel, or fifteen gallon kettle, a table spoonful of slacked lime should be put in while the sap is warming, and before it boils; this promotes the rising of the scum and forming of the grain.

Boiling.—A smart fire should be kept up while the sap is boiling. As the scum rises be careful to skim it off. When the liquor is reduced one half in quantity, lade the second kettle from the end, into the end one; and when the contents of three or four kettles can be contained in

one, let the whole be laded into that, at the end; filling up the empty kettles, without delay, with fresh sap. As the liquor in the end kettle, removed from those which have been mentioned, becomes a syrup, it should be strained through a good blanket or woollen cloth; and care must be taken not to suffer it to boil so long as to be too thick to be strained in this manner. It should, when thus cleansed from its impurities, stand in buckets or other suitable vessels twelve hours or more, that the particles of lime and other remaining sediment may settle to the bottom; after which, it should be so gently poured off into a kettle or boiler, as not to carry with it any of these settlings. However, they need not be wholly lost; they will mostly contain a considerable quantity of sugar or syrup: by pouring fresh sap on them, stirring them well together, and suffering them to stand a while to settle; a great part of the valuable sweets contained in such sediment may be saved. It may be further noted, that when the sap is weak, which is generally the case towards the latter part of the season, it requires more boiling and a higher proof than that collected earlier and of greater strength.

N. B. The method above described was (actually) pursued in the last year, and appeared to answer well; it is nevertheless believed, by a judicious sugar-boiler, that it would be best to avoid letting the syrup stand twelve hours after being strained through a blanket: when the process is begun, the sooner it is completed, in his opinion, the better: the design of its so standing for twelve hours, being chiefly intended to give sufficient time for the particles of lime and other sediment to collect at the bottom of the kettle. It is proposed that lime should be mixed with a quantity of fresh sap in the evening, and be well stirred; the large particles of lime in this case, will be likely to subside before morning, and the clear sap so impregnated may be mixed, the next morning, in proper proportions, in the several kettles; observing, however, that in this mode more lime will be necessary, as less of its strength will be extracted by cold than by hot water.

Graining.—The syrup having stood twelve hours or upwards, is then to be gently poured into a kettle or boiler, as above-mentioned; which would be best placed over a fire made of charcoal as before hinted; unless the kettle is so fixed in a furnace or in such a situation, that the flame can be confined to the bottom; for if it be suffered to pass on the sides, it endangers the syrup's being burned. This operation should also be performed with a smart fire, to be uniformly and equally kept up, in which, as well as in boiling the green sap, the use of butter, hog's-lard, and other fat, is not only very useful and advantageous, but absolutely necessary. When, in the course of boiling, the sap rises towards the top, a piece of fat equal in size to a small nutmeg, thrown in, will keep it down. Particular care should be taken to prevent, by these means, the rising of the syrup when graining, which may require a larger proportion of butter, &c. It is found that the evaporation is much more expeditious, and it is believed that the quantity of sugar made is larger, when a careful guard is kept up to prevent the sap, and particularly the syrup, when graining, from rising; by the timely introduction of a piece of fat as above described. To form a judgment when the syrup is sufficiently boiled, take out with quickness the stirring-stick, which is constantly kept in the boiler for the purpose of taking the proof, rub some of the syrup off the lower end of it with the thumb, and if, on applying the finger thereto it draws into a thread, it may be deemed in a proper state to be laded into a tub or cooler. Then it should be forthwith stirred, and that incessantly, with a stirring-stick about three inches broad, until the grain can be felt between the finger and thumb, when it is in a fit state to be poured into the moulds. The managing of sugar-works in the West-Indies, and in the refining houses in North-America, has been found to require much judgment and experience to conduct the business to the best advantage; indeed, it seems hardly possible, to communicate to persons who have little knowledge of the matter, and in terms clearly to be understood, full information as to the different appearances of the syrup in the time of boiling, and to point out the moment when some material movements or changes ought to be made; nevertheless, from the foregoing hints and directions, which are grounded on observation and experience, it is hoped much may be derived; and that from year to year, greater advances and improvements may be made in this valuable business.

Claying or Whitening the Sugar.—To promote the molasses passing more freely from the sugar, when draining in the moulds, and to improve its colour in two or three days after the moulds are unstopped at the lower end, mix white clay with water so as to reduce it to a thin mortar; with this cover the top of the moulds one inch and a half thick; when this covering appears dry, remove it, and

supply the place with a fresh covering of about two inches thick.

Although it is apprehended that the use of clay as above set forth, particularly in the latter part of the season, will be found beneficial, it may however be prudent to continue or decline the practice, according to the effect or use it appears to be of on a careful trial: the quantity of clay must be proportioned to the manner in which the sugar has been boiled; if high boiled it will require much more clay than if boiled low. It is also thought the use of clay lessens the quantity of sugar, perhaps one fifth part, and may be more or less, according to the knowledge of the person who undertakes the business. It may be further remarked, that if the quantity of sugar be lessened in weight by claying, one fifth part, it is not to be concluded that the whole of this fifth part will be eventually lost; there will be more syrup than there otherwise would have been, independent of the water from the clay that passes through the sugar.

Molasses and Vinegar.—When the trees of the second tapping become poor in quantity and quality, which may be about the tenth of April, or perhaps sooner, then the number of fresh tapped trees will yield a sap, of which may be made good molasses, and also excellent vinegar.

In all sugar plantations it will be advantageous to cut out the different sorts of timber which grow intermixed with the sugar-maple, and even those of that species which are not thriving, promising trees. The timber so cut out will serve for fuel for the boilers, and leave greater openings for the rays of the sun to enter, which will have a tendency to improve and enrich the remaining trees. The ground so cleared of all except the maple-tree, it has been observed, is particularly favourable for pasture and the growth of grass. "Whether this tree is injured or impoverished by repeated tappings," is an enquiry to be expected, and has been frequently made of late, by persons who have anxiously wished for the success of this business. It has been before observed, that it will bear much hardship and abuse, and it may be added, that there are instances, particularly among the old settlements on the North River, of trees which have been tapped for fifty years or upwards, and continue to yield their sap in the season, equal to any brought into use of later time; indeed, it is asserted with confidence, by persons who have had some years experience, that these trees by use, become more valuable, yielding a sap of a richer quality. See SUGAR.

MARBLES are either antique or modern. The following are of the former: Parian, Pentellic, Greek white, translucid white, flexible white, white marble of Luni, white marble of Carrara, white marble of mount Hymettus, black antique, red antique, green antique, red spotted, leek, &c. Of the latter, we have treated under the article LIMESTONE.

MARBLE, Colouring of. Heat is sometimes necessary in communicating the colour. In order to fix the colouring matter into the substance of marble, a lixivium of quick lime, urine, dung, &c. with potash, may be used; common ley is also used; for some colours, spirit of wine is useful, and for others, oily liquors, or common white wine. For blue colour, litmus held in solution may be applied. Dragon's blood, cochineal, and alkanet root may be severally used. If marble be heated, and the following substances rubbed on, the several colours will be formed, viz. dragon's blood for red; gamboge for a yellow; green wax for a green; common brimstone, pitch, and turpentine, for a brown colour.

A fine colour is given by the following: Take sal ammoniac, vitriol, and verdigrise, of each equal quantities. Various other processes may be used for staining marble, which will be noticed hereafter.

In 1778, a patent was granted to Mr. Ritchie, for his invention of an art or method of inlaying *scagliola*, or plaster, in marble or metals, so as to imitate flowers, fruits, trees, birds, beasts, landscapes, and every kind of ornament. This patent is now expired; but, as it is practicable only by statuaries and artists, the inquisitive reader will consult the 10th volume of the *Repertory of Arts and Manufactures*.

MARBLE, polishing of, is performed by first rubbing it well with a free stone, or sand, till the strokes of the saw are worn off, then with pumice stone, and afterwards with emery.

MARBLING of books or paper, is performed thus, which is different from the plan before mentioned (article DYEING.) Dissolve four ounces of gum arabic in 2 quarts of water: then provide several colours mixed with water in pots, and with pencils sprinkle them upon the gum water, which must be put in some broad vessel: then with a stick draw them out, so as to produce a variety. Having done this, hold your book or books, close together, and only dip the edges in, on the top of the water and colours, very lightly, which will produce the effect.

The *Domestic Encyclopedia*, gives the following observations on this subject:

There are several kinds of marbled paper, which vary only in the forms or figures of colouring: some are dotted; others drawn in irregular lines; but the method of tinging them, simply consists in dipping the paper in a thick solution of gum tragacanth, over which the colours are uniformly spread, after having been ground with ox-gall, and spirit of wine.

The paper must first be immersed in clear water, the sheets regularly folded over each other, and covered with a weight. It is now to be carefully laid on the colouring solution, and pressed softly with the hand, that it may bear equally on the whole Next, it must be suspended in order to dry; and, as soon as the moisture is evaporated, the paper is polished by rubbing it with a little soap, and smoothing it either with glass highly burnished, or with a polished agate.

The colours usually employed for red, are, carmine, lake, or vermillion—for yellow, Dutch-pink and yellow ochre—for blue, Prussian-blue and verditer—for green, verdigrise, a mixture of Dutch-pink, and Prussian-blue, in various proportions—for orange, the orange-lake, or a composition of vermillion, or red-lead, with Dutch-pink—and lastly, for purple, rose-pink and Prussian-blue.

These different colours are first to be finely triturated with spirit of wine, when a small proportion of gall is to be added, and the grinding of the whole repeated. The proper quantity of gall can be easily ascertained by comparative trials; because there must be only such a proportion of it used, as will suffer the spots of the various tinging matters to unite, when sprinkled on the solution of tragacanth, without intermixing, or running into each other. The whole being thus prepared, the solution is to be poured into different vessels, according to the colours employed, which are to be sprinkled on the surface; and the process of marbling is completed by laying the paper on the mixture, in the manner above directed.

Marbling on wood or japanning, according to Imison.—Take of the best transparent yellow amber, what quantity you please; beat it to a powder; put it into a clean crucible that is glazed within; let it melt over a gentle charcoal fire; and stir it well, to keep it from burning; then pour it upon a smooth clean marble table, let it cool, and beat it again to powder. Take afterwards clean turpentine, and, in a glass, warm it in a sand heat; put into it the beaten amber; let them simmer, and dissolve gently together, till they are of a consistence fit to be used with a pencil; strain them through a cloth, and you will have the finest varnish possible; and although it be of a brownish colour, yet, when laid on, it has a fine clear gloss.

The colours wherewith you are to marble, are the following; lamp-black, brown-red, ochre, vermillion, which are to be ground with linseed oil; and white lead, ground with oil of almonds.

For a white; lay your first ground with linseed oil, and if there are any holes in the wood, fill them up with chalk tempered with size. For a black ground, lay it first with lamp-black and size; when the ground is dry, mix the vermilion with the above described varnish, and with a hair pencil lay it on with an even and quick hand; repeat this three or four times till it is bright and fine, and lay the varnish, by itself, over it twice, or thrice; then mix your other colours with the varnish, in an oyster-shell, or in little cups; and with them marble upon the ground you have prepared, in imitation of any thing you please.

To marble upon wood, according to Imison.—Take the white of eggs, and beat them up until you can write or draw therewith; then with a pencil, or feather, draw what veins you please upon the wood; after it it dried and hardened for two hours, take quick-lime, and mix it well together with wine; and with a brush, or pencil, paint the wood all over: after it is thoroughly dry, rub it with a scrubbing-brush, so that both the lime and the whites of the eggs may come off together; then rub it with a linen rag, until it is smooth and fine; after which, you may lay over a thin varnish, and you will have a fine marble wood. Or,

Grind white-lead, or chalk together, with water, upon a marble very fine; then mix it up with the whites of well-beaten eggs, wherewith paint, or marble, as you think proper; when dry, strike it over with a ley made of lime and urine, and this will give the wood a brown-red colour: upon this colour you may, when dry, marble again with the whites of eggs; and again, when dry, give it another brush with the ley: after you have, with a scrubbing-brush, rubbed off the marbling with whites of eggs, you may strike once more all over with the ley; and your work, when dry and polished, will look very agreeable, and of a fine marbling.

To imitate marble upon ivory, according to Imison.—Melt bees-wax and tallow together, or else yellow and white bees-wax, and lay it over your ivory; then with an ivory bodkin, open the strokes

that are to imitate marble; pour the solution of some metal or other on them, and let it stand a little while; then pour it off, and when it is dry, cover those strokes again with wax, and open some other veins with your bodkin for another metallic solution; and this repeat to the number of colours you design to give it.

N. B. The solution of gold gives it a purple; of copper, a green; of silver, a lead-black; of iron, a yellow and brown colour. These solutions well managed, and applied on ivory, will entirely answer the design of the artist.

By this method you may imitate tortoise shell, and several other things, on ivory.

To imitate marble, according to Imison.—Take plaster of Paris, quick-lime, salt, ox-blood, stones of different colours, also pieces of glass, all beat to powder, and mixed up to the consistence of a paste, with vinegar, beer, or sour milk, and then lay it into tables, pillars, or what you will; let it stand until it is thoroughly dry; then rub it with a pumice, and polish it with tripoli, giving it the finishing stroke by rubbing it over with leather and oil. Or,

With finely pulverized plaster of Paris, and size of parchment, make a paste; mix with it as many colours as you please; spread it with a trowel over a board, and when dry proceed as before.

To imitate marble, in sulphur, according to Imison.—To do this, you must provide yourself with a flat and smooth piece of marble, on which make a border or wall, to encompass either a square or oval table, which you may do either with wax or clay. When this is done, provide, and have in readiness, several sorts of colours, each separately reduced to a fine powder; as for example; white lead, vermilion, lake, orpiment, masticot, smalt, Prussian blue, and such like colours. After you are provided with them, melt, on a slow fire, in several glazed pipkins, some sulphur; put, in each, one particular sort of colour, and stir it well together; then, having before oiled the marble all over within the border, drop with one colour, quickly, spots upon it, of larger and less sizes; then take another colour, and do as before; and so on, till the stone is covered with spots of all the colours you design to use: then you must conclude what colour the mass or ground of your table is to be; if you would have it of a grey colour, then take fine sifted ashes, and mix it up with melted sulphur; or if of red, with red ochre; if white, with white lead; if black, with lamp black, or ivory black. Your sulphur for the ground must be pretty hot, so that the drops upon the stone may unite and incorporate together; when you have poured your ground even all over, then, if you will, put a thin wainscot board upon it; this must be done whilst the sulphur is hot, making also the board hot, which must be thoroughly dry, in order to cause the sulphur to stick the better to it; and when it is cold, polish it with oil and a cloth, and it will look very beautiful.

To paint on wood in imitation of marble, according to Imison.—First lay a ground (repeating it seven or eight times) with white; then marble it with what colours you please, after you have tempered them with the white of eggs and mixed a little saffron water therewith. If you are not used to marbling with a pencil, you may pour one sort of colour, here and there a little, upon the white prepared table, then, holding and turning it shelving, the colour will disperse all over the ground, in a variety of veins; then, with another colour, proceed in the same manner; and so, with as many as you think proper: after it is dry, you may, with a pencil, give it a finishing, by mending such places as are faulty; then you may lay on a varnish, and polish it in the best manner you can.

MARINE ACID. See MURIATIC ACID.

MARINER'S COMPASS. See MAGNETISM.

MARL. See AGRICULTURE.

MARMALADE, SCOTCH.—Of the different kinds of Marmalade, the Scotch is preferred. It is prepared thus:

Take the same weight of oranges, as of sugar; grate one half of the roughest part of the oranges, and pour boiling water over them. Cut the fruit across as a lemon for punch, and squeeze them through a sieve, boil the skins tender, and scrape the inside all out; then cut them into very small chips, and let them boil until they are transparent. Then put in the juice, and the water strained from the gratings, and let all boil together until the juice jellies, which you will know by cooling a little of it in a saucer.

MARTIAL VITRIOL. See COPPERAS, IRON.

MASSICOT. See LEAD.

MASTICH VARNISH See VARNISH.

MASTICH.

The pistachia lentiscus is a small tree, about ten or twelve feet high, that grows in several of the islands of the Archipelago, but is cultivated with peculiar care and success in the island of Chio. In the month of August transverse incisions are made in the bark of this tree, from which there oozes out, in the space of a few

hours, a pellucid resin. This resin is called mastich, and when pure is in the form of little round drops or tears, of a very pale amber colour; a piece recently broken is quite transparent, but by exposure to the air it becomes somewhat pulverulent superficially, and hence semitransparent. Its specific gravity is 1.074. This resin, especially when gently warmed, has a faint but not unpleasant odour, which becomes stronger and more grateful when it is melted; it has scarcely any sensible flavour; when masticated it grows soft like wax, and acquires an ivory whiteness; water boiled upon it becomes impregnated with its odour, but the mastich loses hardly any weight by the process.

By digestion with alcohol it is separated into two portions; the one soluble in this fluid, and the other insoluble; the former composes about $\frac{4}{5}$ of the whole, and is pure rosin; the latter in most of its properties closely resemble caoutchouc. The presence of this substance in mastich was first remarked by Kunde, an apothecary of Berlin, whose observations have since been confirmed by Mr. Matthews. After solution of the resin in alcohol, an inflammable residue is left behind, of a white colour, considerably elastic and adhesive; when heated it becomes brown, emitting an inflammable gas, and in this state greatly resembles common caoutchouc, except in being slightly glutinous. It is perfectly soluble in washed sulphuric ether, from which it is precipitable by alcohol in the form of a white curd. It is wholly insoluble in water.

In the Turkish dominions mastich is in great request among the women, as a masticatory, and the produce of the Chian plantations is said to be appropriated to the use of the emperor's seraglio. In the other countries of Europe it is employed medicinally in fumigations, and by painters and other artists in the composition of the tougher kinds of varnishes.

MASHING. See Brewing.

MASHING MACHINE, American.—The following patented machine for mashing, obtained by Mr. Ellis of New-Jersey, we thought worth noticing, as much labour and expense is saved by its use.

The principal parts of this machine consist of two horizontal rollers, one above the other, which move on pivots in the extremities of two perpendicular bars; round the rollers move one or more bands, having rakes fastened to them, which by the turning of the bands move upwards and downwards, thereby mashing the malt. One of the perpendicular bars moves on a pivot in the centre of the malt tub, and receives its motion from a cog wheel at the extremity of the upper roller, moving in a double cog wheel, above the centre of which is the perpendicular bar in the middle of the tub: the upper cogs of the last mentioned wheel move in cogs at the extremity of the shaft which receives its motion from a horse or other power.

MATCHING. A method of preparing vessels for the preservation of wines, cyder, or similar liquors, from becoming sour. It is effected in the following manner: Let any quantity of sulphur be melted in an iron ladle; and, as soon as it is liquefied, slips of coarse linen cloth are to be dipped in it; which, when taken out and cooled, are called *matches*. One of these slips is now to be lighted, and suspended in the bung-hole of a cask, which ought to be slightly stopped, till the *match* is consumed; when the hole may be closed, and the vessel be suffered to stand for one or two hours. On opening the bung-hole, it will be found that the sulphur has communicated to the whole cask a very pungent, though suffocating and acid, odour.

The vessel may next be filled with small wine, newly fermented; and, on carefully closing it, the liquor will speedily clarify. This method is very commonly practised in different parts of England, and is said to be very useful; as many poor wines may thus be preserved potable for a considerable time. We doubt, however, its salubrity; and conceive that other articles might be advantageously employed instead of the pernicious fumes of sulphur, which render both wine and cyder alike unwholesome, especially for persons affected with diseases of the breast or lungs.

MEAD, ORANGE, to make.—Communicated by Dr. Mease.

Take of honey 68 lb. soft water 17 gallons, whites of 12 eggs, beat up with a quart of the above liquor, while cold. Boil the whole for an hour, skimming it from time to time. Then pour the boiling liquor on the thin rinds of 1 doz. of Seville oranges, and cover it up. When it is about lukewarm, add the juice of 8 doz. of Seville oranges, and of 6 lemons and their thin rinds. Stir the whole well, and cover it till it is cooled down to 96° of Farenheit's thermometer, when a pint of good ale yeast is to be put on a toast, and added to it. After it has fermented two or three days, or till the froth begins to sink, then strain it off from the press into a clean cask, and let it stand 6 months

before it is bottled. Draw it off carefully with a syphon, without disturbing the grounds. See HYDROMEL.

MECHANICAL POWERS.—The mechanical powers are simple engines, that enable men to raise weights, move heavy bodies, and overcome resistances, which they could not do with their natural strength alone.

Their importance to society is incalculable. Every machine whatever is composed of one or more of them; sometimes of several combined together.

In considering this science, it will be necessary at first to take some things for granted that are not strictly true; and after the theory is established, to make the proper allowances for them.

1. That a small portion of the earth's surface, which is spherical, may be considered as a plane.

2. That all bodies be supposed to descend in lines parallel to each other; for though all bodies really tend to the centre of the earth, yet the distance from which they fall is comparatively so small, that their inclination towards each other is inconsiderable.

3. That all planes be considered as perfectly smooth; levers to be inflexible, and without thickness or weight; cords perfectly pliable; and machines without friction and inertia.

Three things are always to be considered in treating of mechanical engines: the *weight* to be raised; the *power* by which it is to be raised; and the *instrument* or *engine* by which this is to be effected.

The mechanical powers are generally reckoned six; the *lever*, the *pulley*, the *wheel* and *axis*, the *inclined plane*, the *wedge*, and the *screw*.

These perhaps may be reduced to two; for the pulley and wheel are only assemblages of levers, and the wedge and screw are inclined planes.

To calculate the power of a machine, it is usually considered in a state of equilibrium; that is, in the state when the power which is to overcome the resistance, just balances it. Having discovered what quantity of power will be requisite for this purpose, it will then be necessary to add so much more as to overcome the friction and weight of the machine itself, and to give the necessary velocity.

Of the Lever.—The lever is the simplest of all machines, and is only a straight bar of iron, wood, or other material, supported on, and moveable round, a prop called the fulcrum.

In the lever, there are three circumstances to be principally attended to: 1. The fulcrum, or prop, by which it is supported, or on which it turns as an axis, or centre of motion: 2. The power to raise and support the weight: 3. The resistance or weight to be raised or sustained.

The points of suspension are those points where the weights really are, or from which they hang freely.

The power and the weight are always supposed to act at right angles to the lever, except it be otherwise expressed.

The lever is distinguished into three sorts, according to the different situations of the fulcrum, or prop, and the power, with respect to each other.

1. When the prop is placed between the power and the weight.

2. When the prop is at one end of the lever, the power at the other, and the weight between them.

3. When the prop is at one end, the weight at the other, and the power applied between them.

A poker, in stirring the fire, is a lever of the first sort; the bar of the grate upon which it rests is the fulcrum; the fire, the weight to be overcome; and the hand is the power. The lever of the first kind is principally used for loosening large stones; or to raise great weights to small heights, in order to get ropes under them, or other means of raising them to still greater heights: it is the most common species of lever.

ABC (Plate I. fig. 6) is this lever; in which B is the fulcrum, A the end at which the power is applied, and C the end where the weight acts.

To find when an equilibrium will take place between the power and the weight, in this as well as in every other species of lever, it is necessary to recur to what has formerly been mentioned; that when the momenta, or quantities of force, in two bodies were equal, they would balance each other. Now, let us consider when this will take place in the lever. Suppose the lever AB (fig. 7) to be turned on its axis, or fulcrum, so as to come into the situation DC; as the end D is farthest from the centre of motion, and as it has moved through the arch AD in the same time as the end B moved through the arch BC, it is evident that the velocity of AB must have been greater than that of B. But the momenta being the products of the quantities of matter multiplied into the velocities, the greater the velocity, the less the quantity of matter need be to get the same product. Therefore, as the velocity of A is the greatest, it will require less matter to produce an equilibrium than B.

Let us next see how much more weight

B will require than A, to balance. As the radii of circles are in proportion to their circumferences, they are also proportionate to similar parts of them; therefore, as the arches AD, CB, are similar, the radius, or arm, DE, bears the same proportion to EC that the arch AD bears to CB. But the arches AD and CB represent the velocities of the ends of the lever, because they are the spaces which they moved over in the same time; therefore the arms DE and EC may also represent these velocities.

It is evident then, that an equilibrium will take place, when the length of the arm AE, multiplied into the power A, shall equal EB, multiplied into the weight B; and consequently, that the shorter EB is, the greater must be the weight B; that is, the power and the weight must be to each other inversely, as their distances from the fulcrum. Thus, suppose AE, the distance of the power from the prop, to be twenty inches, and EB, the distance of the weight from the prop, to be eight inches, also the weight to be raised at B to be five pounds; then the power to be applied at A, must be two pounds; because the distance of the weight from the fulcrum eight, multiplied into the weight five, makes forty; therefore twenty, the distance of the power from the prop, must be multiplied by two, to get an equal product; which will produce an equilibrium.

It is obvious, that while the distance of the power from the prop exceeds that of the weight from the prop, a power less than the weight will raise it, so that then the lever affords a mechanical advantage: when the distance of the power is less than that of the weight from the prop, the power must be greater than the weight to raise it; when both the arms are equal, the power and the weight must be equal, to be in equilibrio.

The second kind of lever, when the weight is between the fulcrum and the power, is represented by Fig. 8, Plate I. in which A is the fulcrum, B the weight, and C the power. The advantage gained by this lever, as in the first, is as great as the distance of the power from the prop exceeds the distance of the weight from it. Thus, if the point *a*, on which the power acts, be seven times as far from A as the point Z, on which the weight acts, then one pound applied at C will raise seven pounds at B.

This lever shows the reason why two men carrying a burden upon a stick between them, bear shares of the burden which are to one another in the inverse proportion of their distances from it. For it is well known, that the nearer either of them is to the burden, the greater share he bears of it; and if he go directly under it, he bears the whole. So if one man be at A, and the other at *a*, having the pole or stick resting on their shoulders: if the burden or weight B be placed five times as near the man at A, as it is to the man *a*, the former will bear five times as much weight as the latter.

This is likewise applicable to the case of two horses of unequal strength to be so yoked, as that each horse may draw a part proportionable to his strength; which is done by so dividing the beam they pull, that the point of traction may be as much nearer to the stronger horse than to the weaker, as the strength of the former exceeds that of the latter.

To this kind of lever may be reduced oars, rudders of ships, doors turning upon hinges, cutting-knives which are fixed at the point, &c.

If in this lever we suppose the power and weight to change places, so that the power may be between the weight and the prop, it will become a lever of the third kind; in which, that there may be a balance between the power and the weight, the intensity of the power must exceed the intensity of the weight just as much as the distance of the weight from the prop exceeds the distance of the power. Thus, let E, (Fig. 9.) be the prop of the lever EF, and W a weight of one pound, placed three times as far from the prop as the power P acts at F, by the cord going over the fixed pulley D: in this case, the power must be equal to three pounds, in order to support the weight of one pound.

To this sort of lever are generally referred the bones of a man's arm; for when he lifts a weight by the hand, the muscle that exerts its force to raise that weight, is fixed to the bone about one tenth part as far below the elbow as the hand is. And the elbow being the centre round which the lower part of the arm turns, the muscle must therefore exert a force ten times as great as the weight that is raised.

As this kind of lever is a disadvantage to the moving power, it is used as little as possible; but in some cases it cannot be avoided; such as that of a ladder, which being fixed at one end, is by the strength of a man's arms reared against a wall.

What is called the *hammer-lever*, differs in nothing but its form, from a lever of the first kind. Its name is derived from its use, that of drawing a nail out of wood by a hammer.

Suppose the shaft of a hammer to be five times as long as the iron part which draws the nail, the lower part resting on the board, as a fulcrum; then, by pulling backwards the end of the shaft, a man will draw a nail with one-fifth part of the power that he must use to pull it out with a pair of pincers; in which case, the nail would move as fast as his hand; but with the hammer, the hand moves five times as much as the nail, by the time that the nail is drawn out.

Let ACB (Fig. 10.) represent a lever of this sort, bended at C, which is its prop, or centre of motion P is a power acting upon the longer arm AC, at A, by means of the cord DA going over the pulley D; and W is a weight or resistance acting upon the end B of the shorter arm CB. If the power be to the weight as CB is to CA, they are in equilibrio: thus, suppose W to be five pounds, acting at the distance of one foot from the centre of motion C, and P to be one pound, acting at A, five feet from the centre C, the power and weight will just balance each other.

Thus we see, that in every species of lever there will be an equilibrium, when the power is to the weight as the distance of the weight from the fulcrum is to the distance of the power from the fulcrum

In making experiments on the mechanic powers, some difficulties arise from the weight of the materials; but as it is impossible to find any that are without weight, we take care that they are perfectly balanced themselves, before the weights and powers are applied. The bar, therefore, used in making experiments on levers, has the short end so much thicker than the long arm, as will be sufficient to balance it on the prop

If the weight to be raised be of considerable bulk, and if it be fixed either above or below the end of the lever, it will vary in its intensity, according to the position of the lever. Let AB (Fig 11.) represent a lever having a weight fixed above it, as A, of which the centre of gravity is *a*, and the line of direction *a b*; then is *b* the point in the lever on which the weight acts: but if the lever is moved into the position CD, the line of direction of the weight will fall nearer to the fulcrum of the lever, and consequently act with less force upon it; but if it is placed in the position EF, the line of direction will fall farther from the fulcrum, and therefore act more on the lever.

On the contrary, it is evident from Fig. 12, that opposite effects take place, when the weight is below the lever.

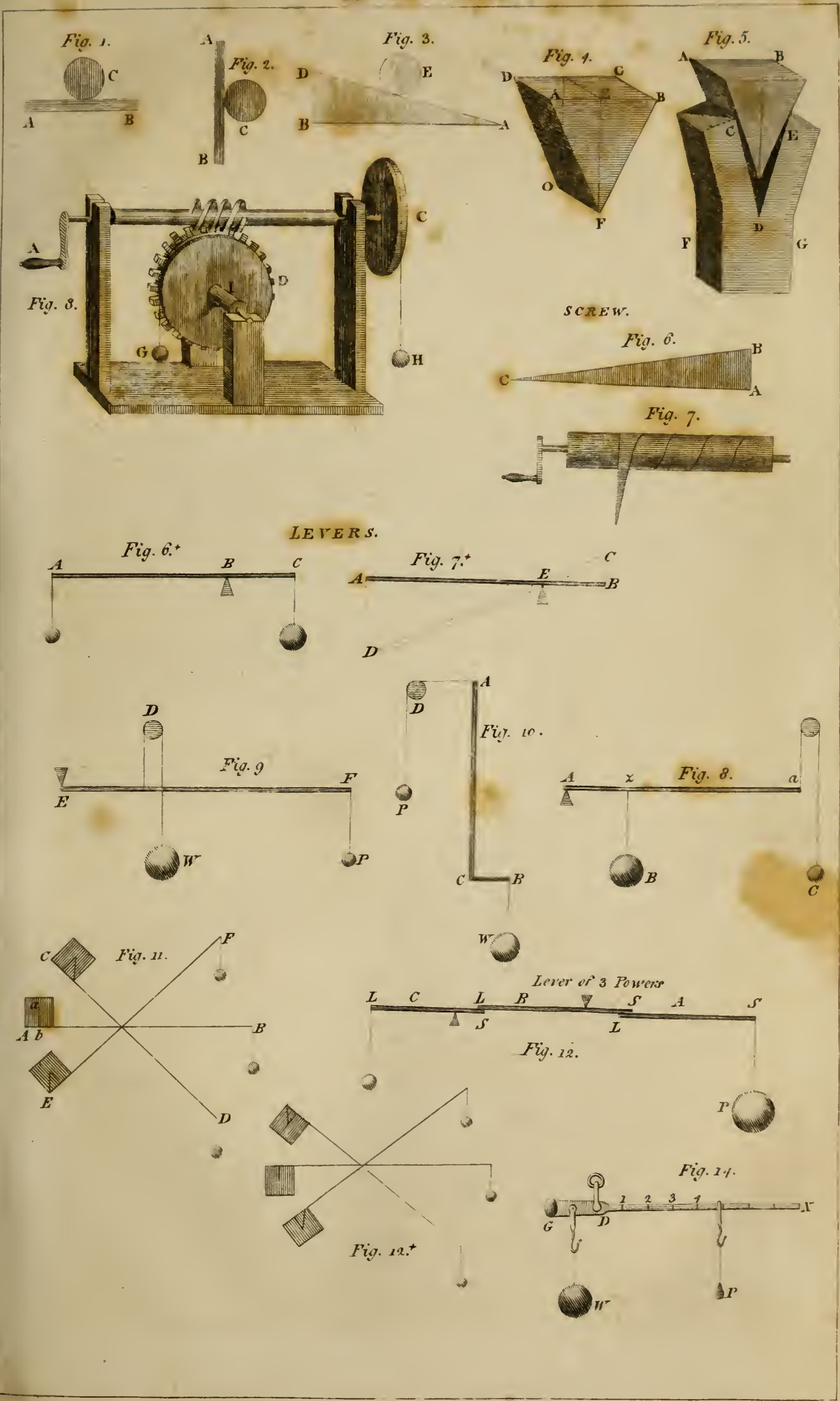
Nothing of this kind can happen, when the weight is suspended from the lever by a rope, because the point of suspension, or point of action, is not altered.

When two draymen carry a barrel on a coulstaff, to which it is suspended by a chain, the point on which the weight acts not being altered by inclining the staff in going up or down hill, there will be no variation in the weight that each man had to support on beginning. But if they carry the barrel upon two dogs, then the weight does not swing, and the centre of gravity is below the lever; therefore the point on which the weight acts, will, by inclining the lever, be made to approach the highest end; and the first man, in going down hill, by having this point removed from him, will be eased in part of his burden; and the last man will have his equally increased.

Hitherto we have supposed that the power and weight acted perpendicularly upon the lever: but if they do not, they act with less force upon it; the power should, therefore, if possible, be always made to act at right angles to the lever.

If several levers be combined together in such a manner, as that a weight being appended to the first lever, may be supported by a power applied to the last, as in Fig. 12, Plate I. which consists of three levers of the first kind, and is so contrived, that a power applied at the point L of the lever C, may sustain a weight at the point S of the lever A, the power must here be to the weight, in a ratio, or proportion, compounded of the several ratios, which those powers that can sustain the weight by the help of each lever, when used singly and apart from the rest, have to the weight. For instance, if the power which can sustain the weight P, by the help of the lever A, be to the weight as 1 to 5; and if the power which can sustain the same weight, by the lever B alone, be to the weight as 1 to 4; and if the power which could sustain the same weight by the lever C, be to the weight as 1 to 5; then the power which will sustain the weight by help of the three levers joined together, will be to the weight in a proportion consisting of the several proportions multiplied together, of 1 to 5, 1 to 4, and 1 to 5; that is of 1 to 100.

For since, in the lever A, a power equal to one-fifth of the weight P pressing down the lever at L, is sufficient to balance the weight, and since it is the same thing whether that power be applied to the lever A at L, or the lever B at S, the point S bearing on the point L, a power equal to one-fifth of the weight P, being applied to the point S of the lever B, will support the weight; but one-fourth of the same power being applied to



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the point L of the lever B, and pushing the same upward, will as effectually depress the point S of the same lever, as if the whole power were applied at S; consequently a power equal to one-fourth of one-fifth, that is, one-twentieth of the weight P, being applied to the point L of the lever B, and pushing up the same, will support the weight: in like manner, it matters not whether that force be applied to the point L of the lever B, or to the point S of the lever C, since, if S be raised, L, which rests on it, must be raised also; but one-fifth of the power applied at the point L of the lever C, and pressing it downwards, will as effectually raise the point S of the same lever, as if the whole power were applied at S, and pushed up the same; consequently a power equal to one-fifth of one-twentieth, that is, one-hundredth part of the weight P, being applied to the point L of the lever C, will balance the weight at the point S of the lever A.

This method of combining levers, is frequently used in machines and instruments, and is of great service, either in obtaining a greater power, or in applying it with more convenience.

The *balance*, an instrument of very extensive use in comparing the weights of bodies is a lever of the first kind, whose arms are of equal length.—The points from which the weights are suspended being equally distant from the centre of motion, will move with equal velocity; consequently, if equal weights be applied, their momenta will be equal, and the balance will remain in equilibrio.

In order to have a balance as perfect as possible, it is necessary to attend to the following circumstances:

1. The arms of the beam ought to be exactly equal, both as to weight and length.

2. The points from which the scales are suspended, should be in a right line, passing through the centre of gravity of the beam; for by this, the weights will act directly against each other, and no part of either will be lost, on account of any oblique direction.

3. If the fulcrum, or point upon which the beam turns, be placed in the centre of gravity of the beam, and if the fulcrum and the points of suspension be in the same right line, the balance will have no tendency to one position more than another, but will rest in any position it may be placed in, whether the scales be on or off, empty or loaded.

If the centre of gravity of the beam, when level, be immediately above the fulcrum, it will overset by the smallest action; that is, the end which is lowest will descend; and it will do this with more swiftness, the higher the centre of gravity be, and the less the points of suspension be loaded.

But if the centre of gravity of the beam be immediately below the fulcrum, the beam will not rest in any position but when level; and if disturbed from that position, and then left at liberty, it will vibrate, and at last come to rest on the level. In a balance, therefore, the fulcrum ought always to be placed a little above the centre of gravity. Its vibrations will be quicker, and its horizontal tendency stronger, the lower the centre of gravity, and the less the weight upon the points of suspension.

4. The friction of the beam upon the axis ought to be as little as possible; because, should the friction be great, it will require a considerable force to overcome it; upon which account, though one weight should a little exceed the other, it will not preponderate, the excess not being sufficient to overcome the friction, and bear down the beam. The axis of motion should be formed with an edge like a knife, and made very hard: these edges are at first made sharp, and then rounded with a fine hone, or piece of buff leather, which causes a sufficient bluntness, or rolling edge. On the regular form and excellence of this axis, depends chiefly the perfection of this instrument.

5. The pivots, which form the axis or fulcrum, should be in a straight line, and at right angles to the beam.

6. The arms should be as long as possible, relatively to their thickness, and the purposes for which they are intended, as the longer they are, the more sensible is the balance.

They should also be made as stiff and inflexible as possible; for if the beam be too weak, it will bend, and become untrue.

7. The rings, or the piece on which the axis bears, should be hard and well polished, parallel to each other, and of an oval form, that the axis may always keep its proper bearing, or remain always at the lowest point.

8. If the arms of a balance be unequal, the weights in equipoise will be unequal in the same proportion. The equality of the arms is of use, in scientific pursuits, chiefly in the making of weights by bisection. A balance with unequal arms will weigh as accurately as another of the same workmanship with equal arms, provided the standard weight itself be first counterpoised, then taken out of the scale, and the thing to be weighed be put into the scale, and adjusted against the

counterpoise. Or, when proportional quantities only are considered, the bodies under examination may be weighed against the weights, taking care always to put the weights in the same scale; for then, though the bodies may not be really equal to the weights, yet their proportions amongst each other will be the same as if they had been accurately so.

9. Very delicate balances are not only useful in nice experiments, but are likewise much more expeditious than others in common weighing. If a pair of scales, with a certain load be barely sensible to one-tenth of a grain, it will require a considerable time to ascertain the weight to that degree of accuracy, because the turn must be observed several times over, and is very small. But if no greater accuracy were required, and scales were used, which would turn with one-hundredth of a grain, a tenth of a grain more or less, would make so great a difference in the turn, that it would be seen immediately.

10. If a balance be found to turn with a certain addition, and is not moved by any smaller weight, a greater sensibility may be given to the balance, by producing a tremulous motion in its parts. Thus, if the edge of a blunt saw, a file, or other similar instrument, be drawn along any part of the case or support of the balance, it will produce a jarring, which will diminish the friction in the moving parts so much, that the turn will be evident with one-third, or one-fourth of the addition that would else have been required. In this way, a beam which would barely turn by the addition of the tenth of a grain, will turn with the thirtieth or fortieth of a grain.

To those who are engaged in making nice philosophical experiments, an accurate balance is of the greatest importance. One of the best ever made, is that belonging to the Royal Society, executed by the late Mr. Ramsden.

The statera, or Roman steel-yard, is a lever of the first kind, and is used for finding the weights of different bodies, by one single weight placed at different distances from the prop or centre of motion D (Fig. 14.) Plate I. For, the shorter arm DG is of such a weight as exactly to counterpoise the longer arm DX. If this arm be divided into as many equal parts as it will contain, each equal to GD, the single weight P (which we may suppose to be one pound) will serve for weighing any thing as heavy as itself, or as many times heavier as there are divisions in the arm DX, or any quantity between its own weight and that quantity. As for example, if P be one pound, and placed at the first division 1 in the arm DX, it will balance one pound in the scale at W; if it be removed to the second division at 2, it will balance two pounds in the scale; if to the third, three pounds; and so on to the end of the arm DX. If any of these integral divisions be subdivided into as many equal parts as a pound contains ounces, and the weight P be placed at any of these subdivisions, so as to counterpoise what is in the scale, the pounds and odd ounces therein will by that means be ascertained.

Of the Wheel and Axle—The wheel and axle is a machine much used, and is made in a variety of forms. It consists of a wheel with an axle fixed to it, so as to turn round with it; the power being applied at the circumference of the wheel, the weight to be raised is fastened to a rope which coils round the axle.

AB (Fig. 1, Plate II.) is a wheel, and CD an axle fixed to it, and which moves round with it. If the rope which goes round the wheel be pulled, and the wheel turned once round, it is evident that as much rope will be drawn off as the circumference of the wheel; but while the wheel turns once round, the axle turns once round; and consequently the rope by which the weight is suspended, will wind once round the axis, and the weight will be raised through a space equal to the circumference of the axis.

The velocity of the power, therefore, will be to that of the weight, as the circumference of the wheel to that of the axis.

That the power and the weight may be in equilibrio, therefore, the power must be to the weight as the circumference of the wheel to that of the axis.

It is proved by geometry, that the circumferences of different circles bear the same proportion to each other as their respective diameters do; consequently the power is to the weight, as the diameter also of the axis to that of the wheel.

Thus, suppose the diameter of the wheel to be eight inches, and the diameter of the axis to be one inch; then one ounce acting as the power P, will balance eight ounces as a weight W; and a small additional force will cause the wheel to turn with its axis, and raise the weight; and for every inch which the weight rises, the power will fall eight inches.

The wheel and axis may be considered as a kind of perpetual lever, of which the fulcrum is the centre of the axis, and the long and short arms the diameter of the wheel and the diameter of the axis. (See Fig. 2, Plate II.)

From this it is evident, that the longer

the wheel, and the smaller the axis, the stronger is the power of this machine; but then the weight must rise slower in proportion.

A capstan is a cylinder of wood, with holes in it, into which are put bars, or levers, to turn it round; these are like the spokes of a wheel without the rim.

Sometimes the axis is turned by a winch fastened to it, which, in this respect, serves for a wheel, and is more powerful, in proportion to the largeness of the circle it describes, compared with the diameter of the axle.

When the parts of the axis differ in thickness, and weights are suspended at the different parts, they may be sustained by one and the same power applied to the circumference of the wheel, provided the product arising from the multiplication of the power into the diameter of the wheel, be equal to the sum of the products arising from the multiplication of the several weights into the diameters of those parts of the axis from which they are suspended.

In considering the theory of the wheel and axle, we have supposed the rope that goes round the axle to have no sensible thickness; but as in practice this cannot be the case, if it is a thick rope, or if there be several folds of it round the axis, you must measure to the middle of the outside rope, to obtain the diameter of the axis, for the distance of the weight from the centre, is increased by the coiling up of the rope.

If teeth are cut in the circumference of a wheel, and if they work in the teeth of another wheel of the same size as Fig. 3, Plate II. it is evident that both the wheels will revolve in the same time; and the weight appended to the axle of the wheel B, will be raised in the same time as if the axle had been fixed to the wheel A. But if the teeth of the second wheel be made to work in teeth made in the axle of the first, as at Fig. 4, Plate II. as every part of the circumference of the second wheel is applied successively to the circumference of the axle of the first, and as the former is much greater than the latter, it is evident that the first wheel must go round as many times more than the second, as the circumference of the second wheel exceeds that of the first axle.

In order to a balance here, the power must be to the weight, as the product of the circumferences, or diameters of the two axles multiplied together, is to the circumferences or diameters of the two wheels.

This will become sufficiently clear, if it be considered as a compound lever, which was explained above. Instead of a combination of two wheels, three or four wheels may work in each other, or any number; and by thus increasing the number of wheels, or by proportioning the wheels to the axis, any degree of power may be acquired.

To this sort of engine belong all cranes for raising great weights; and in this case the wheel may have cogs all round it, instead of handles; and a small lanthorn, or trundle, may be made to work in the cogs, and be turned by a winch; which will make the power of the engine to exceed the power of the man who works it, as much as the number of revolutions of the winch exceeds those of the axle CD, (Plate II. Fig. 1) when multiplied by the excess of the length of the winch above the length of the semidiameter of the axle, added to the semidiameter or half-thickness of the rope K, by which the weight is drawn up. Thus, suppose the diameter of the rope and axle taken together to be 13 inches, and consequently half their diameter to $6\frac{1}{2}$ inches, so that the weight W will hang at $6\frac{1}{2}$ inches perpendicular distance from below the centre of the axle. Now, let us suppose the wheel AB, which is fixed on the axle, to have 80 cogs, and to be turned by means of a winch $6\frac{1}{2}$ inches long, fixed on the axle of a trundle of eight staves, or rounds, working in the cogs of the wheel; here it is plain, that the winch and trundle would make ten revolutions for one of the wheel AB, and its axis CD, on which the rope K winds in raising the weight W; and the winch being no longer than the sum of the semi-diameters of the great axle and rope, the trundle could have no more power on the wheel than a man could have by pulling it round by the edge, because the winch would have no greater velocity than the edge of the wheel has, which we here suppose to be ten times as great as the velocity of the rising weight; so that, in this case, the power gained would be as is 10 to 1. But if the length of the winch be 13 inches, the power gained will be as 20 to 1; if $19\frac{1}{2}$ inches (which is long enough for any man to work by), the power gained will be as 30 to 1; that is, a man could raise 30 times as much by such an engine, as he could do by his natural strength without it, because the velocity of the handle of the winch would be 30 times as great as the velocity of the rising weight; the absolute force of any engine being in proportion of the velocity of the power, to the velocity of the weight raised by it. But then, just as much power or advantage as is gained by the engine, so much

time is lost in working it; which is common in all mechanical cases whatever.

In this sort of machines, it is requisite to have a ratchet wheel on the end of the axle C, with a catch to fall into its teeth; which will at any time support the weight, and keep it from descending, if the person who turns the handle should, through inadvertency or carelessness, quit his hold while the weight is raising. By this means, the danger is prevented, which might otherwise happen by the running down of the weight when left at liberty.

Of the Pulley.—The pulley is a small wheel turning on an axis, with a drawing rope passing over it: the small wheel is usually called a *sheeve*, and is so fixed in a *box*, or *block*, as to be moveable round a pin passing through its centre.

Pullies are of two kinds:—1. *Fixed*, which do not move out of their places; 2. *Moveable*, which rise and fall with the weight.

When a pulley is fixed, as Fig. 5, Plate II. two equal weights suspended to the ends of a rope passing over it, will balance each other, for they stretch the rope equally, and if either of them be pulled down through any given space, the other will rise through an equal space in the same time; and consequently, as the velocities of both are equal, they must balance each other. This kind of pulley, therefore, gives no mechanical advantage; so that you can raise no greater weight by it than you could do by your natural strength. Its use consists in changing the direction of the power, and sometimes enabling it to be applied with more convenience. By it, a man may raise a weight to any point, without moving from the place he is in; whereas, otherwise, he would have been obliged to ascend with the weight: it also enables several men together to apply their strength to the weight by means of the rope.

The moveable pulley represented at A (Fig. 6, Plate II.), is fixed to the weight W, and rises and falls with it. In comparing this to a lever, the fulcrum must be considered as at A (Fig 6); the weight acts upon the centre c, and the power is applied at the extremity of the lever D. The power, therefore, being twice as far from the fulcrum as the weight is, the proportion between the power and weight, in order to balance each other, must be as 1 to 2. Whence it appears, that the use of this pulley doubles the power, and that a man may raise twice as much by it as by his strength alone. Or it may be considered in this way—Every moveable pulley hangs by two ropes equally stretched, and which must, consequently, bear equal parts of the weight; but the rope AB being made fast at B, half the weight is sustained by it, and the other part of the rope, to which the power is applied, has but half the weight to support; consequently the advantage gained by this pulley is as 2 to 1.

When the upper and fixed block contains two pullies. which only turn upon their axis, and the lower moveable block contains also two, which not only turn on their axis, but rise with the weight F (Fig. 7, Plate II.), the advantage gained is as 4 to 1. For each lower pulley will be acted upon by an equal part of the weight; and because in each pulley that moves with the weight, a double increase of power is gained, the force by which F may be sustained, will be equal to half the weight divided by the number of lower pullies; that is, as twice the number of lower pullies is to 1, so is the weight suspended to the power.

But if the extremity C (Fig. 8, Plate II.) be fixed to the lower block, it will sustain half as much as a pulley; consequently here the rule will be, as twice the number of pullies adding unity is to 1, so is the weight to the power.

These rules hold good, whatever may be the number of pullies in the blocks.

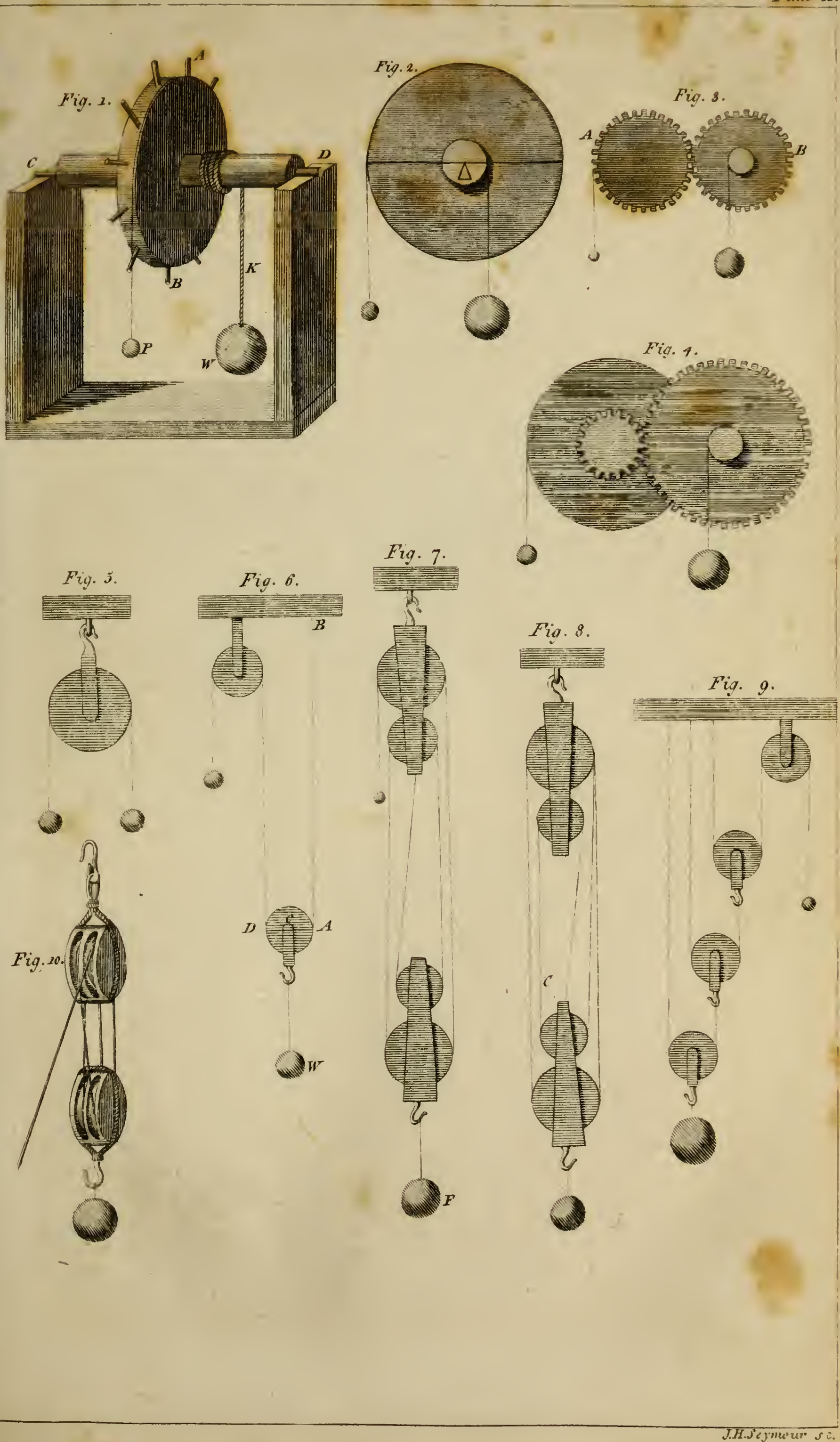
If, instead of one rope going round all the pullies, the rope belonging to each pulley be made fast at top, as in Fig. 9, Plate II. a different proportion between the power and the weight will take place. Here it is evident, that each pulley doubles the power: thus, if there are two pullies, the power will sustain four times the weight; if three pullies, eight times the weight; if four pullies, sixteen times; and so on.

When pullies in blocks are placed perpendicularly under each other, on separate pins, they occupy considerable space, and would not in general answer; it is, therefore, common to place all the pullies in each block on the same pin, by the side of each other, as in Fig. 10, Plate II.; but the advantage, and rule for the power, are the same here as in Fig. 7 and 8.

A pair of blocks with the rope fastened round it, is commonly called a *tackle*.

The Inclined Plane.—This mechanical power is of very great use in rolling up heavy bodies, such as casks, wheel-barrows, &c. It is formed by placing boards, or earth, in a sloping direction.

The force wherewith a body descends upon an inclined plane, is to the force of its absolute gravity, by which it would descend perpendicularly in free space, as the height of the plane is to its length. For suppose the plane AB (Fig. 1, Plate



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I.) to be parallel to the horizon, the cylinder C will keep at rest on any part of the plane where it is laid. If the plane be placed perpendicularly, as AB, Fig 2, the cylinder C will descend with its whole force of gravity, because the plane contributes nothing to its support or hindrance; and therefore it would require a power equal to its whole weight to keep it from descending.

Let AB (Fig 3) be a plane parallel to the horizon, and AD a plane inclined to it; and suppose the whole length AD to be three times as great as the perpendicular DB. In this case, the cylinder E will be supported upon the plane DA, and kept from rolling, by a power equal to a third part of the weight of the cylinder; therefore a weight may be rolled up this inclined plane, by a third part of the power which would be sufficient to draw it up by the side of an upright wall.

It must also be evident, that the less the angle of elevation, or the gentler the ascent is, the greater will be the weight which a given power can draw up; for the steeper the inclined plane is, the less does it support of the weight; and the greater the tendency which the weight has to roll, consequently the more difficult for the power to support it: the advantage gained by this mechanical power, therefore, is as great as its length exceeds its perpendicular height.

To the inclined plane may be reduced all hatchets, chisels, and other edge-tools.

The Wedge.—The fifth mechanical power or machine is the wedge, which may be considered as two equally inclined planes, joined together at their bases; then DC (Fig. 4) is the whole thickness of the wedge at its back ABCD, where the power is applied; EF is the depth or height of the wedge; BF the length of one of its sides; and OF is its sharp edge, which is entered into the wood intended to be split, by the force of a hammer or mallet striking perpendicularly on its back. Thus, AB (Fig 5) is a wedge driven into the cleft CED of the wood FG.

When the wood does not cleave at any distance before the wedge, there will be an equilibrium between the power impelling the wedge downward and the resistance of the wood acting against the two sides of the wedge, when the power is to the resistance as half the thickness of the wedge at its back is to the length of either of its sides; because the resistance then acts perpendicular to the sides of the wedge. But when the resistance on each side acts parallel to the back, the power that balances the resistances on both sides will be, as the length of the whole back of the wedge is to double its perpendicular height.

When the wood cleaves at any distance before the wedge (as it generally does) the power impelling the wedge will not be to the resistance of the wood as the length on the back of the wedge is to the length of both its sides, but as half the length of the back is to the length of either side of the cleft, estimated from the top or acting part of the wedge. For, if we suppose the wedge to be lengthened down from the top CE, to the bottom of the cleft at D, the same proportion will hold; namely, that the power will be to the resistance as half the length of the back of the wedge is to the length of either of its sides: or, which amounts to the same thing, as the whole length of the back is to the length of both the sides.

The wedge is a very great mechanical power, since not only wood, but even rocks, can be split by it; which it would be impossible to effect by the lever, wheel, and axle, or pulley; for the force of the blow, or stroke, shakes the cohering parts, and thereby makes them separate more easily.

The Screw.—The sixth and last mechanical power is the screw; which cannot properly be called a simple machine, because it is never used without the application of a lever or winch to assist in turning it; and then it becomes a compound engine of a very great force, either in pressing the parts of bodies closer together, or in raising great weights. It may be conceived to be made by cutting a piece of paper, ABC (Fig 6) into the form of an inclined plane or half wedge; and then wrapping it round a cylinder (Fig. 7), the edge of the paper AC will form a spiral line round the cylinder, which will give the thread of the screw. It being evident that the winch must turn the cylinder once round, before the weight of resistance can be moved from one spiral winding to another, as from d to c: therefore, as much as the circumference of a circle described by the handle of the winch is greater than the interval or distance between the spirals, so much is the force of the screw. Thus, supposing the distance of the spirals to be half an inch, and the length of the winch twelve inches, the circle described by the handle of the winch where the power acts, will be 76 inches nearly, or about 152 half inches; and consequently 152 times as great as the distance between the spirals: and therefore a power at the handle, whose intensity is equal to no more than a single pound, will balance 152 pounds acting against

the screw; and as much additional force as is sufficient to overcome the friction, will raise the 152 pounds; and the velocity of the power will be to the velocity of the weight, as 152 to 1. Hence it appears, that the longer the winch is, and the nearer the spirals are to one another, so much the greater is the force of the screw.

A machine for shewing the force or power of the screw may be contrived in the following manner:—Let the wheel C have a screw Fig. 8, on its axis, working in the teeth of the wheel D, which suppose to be 48 in number It is plain, that for every time the wheel C and screw are turned round by the winch A, the wheel D will be movéd one tooth by the screw; and therefore, in 48 revolutions of the winch, the wheel D will be turned once round. Then, if the circumference of a circle, described by the handle of the winch A, be equal to the circumference of a groove round the wheel D, the velocity of the handle will be 48 times as great as the velocity of any given point in the groove. Consequently, if a line G goes round the groove, and has a weight of 48 pounds hung to it, a power equal to 1 pound at the handle will balance and support the weight. To prove this by experiment, let the circumferences of the grooves of the wheels C and D be equal to one another; and then if a weight H, of one pound, be suspended by a line going round the groove of the wheel C, it will balance a weight of 48 pounds hanging by the line G; and a small addition to the weight H will cause it to descend, and so raise up the other weight.

If a line G, instead of going round the groove of the wheel D, goes round its axle I, the power of the machine will be as much increased as the circumference of the groove exceeds the circumference of the axle: which supposing it to be six times, then one pound at H will balance six times 48, or 288 pounds, hung to the line on the axle: and hence the power or advantage of this machine will be as 288 to 1. That is to say, a man, who by his natural strength could lift an hundred weight, will be able to raise 288 cwts. by this engine. If a system of pullies were applied to the cord H, the power would be increased to an amazing degree.

When a screw acts in a wheel in this manner, it is called an endless screw.

When it is not employed in turning a wheel, it consists of two parts: the first is called the male, or outside screw, being cut in such a manner, as to have a prominent part going round the cylinder in a spiral manner; which prominent part is called the thread of the screw; the other part, which is called the female, or inside screw, is a solid body, containing a hollow cylinder, whose concave surface is cut in the same manner as the convex surface of the male screw, so that the prominent parts of the one may fit the concave parts of the other.

A very considerable degree of friction always acts against the power in a screw; but this is fully compensated by other advantages; for on this account the screw continues to sustain a weight, even after the power is removed, or ceases to act, and presses upon the body against which it is driven. Hence the screw will sustain very great weights, insomuch, that several screws, properly applied, would support a large building, whilst the foundation was mending, or renewed.

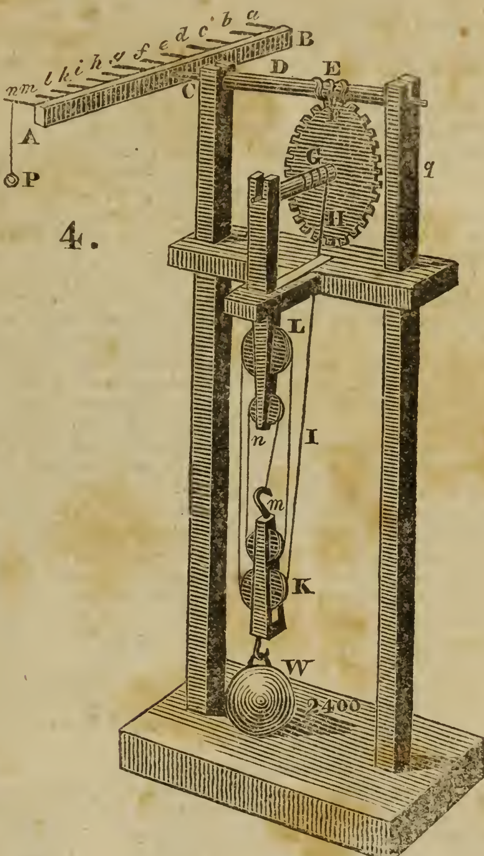
Messrs. Carr and Hancock have obtained a patent for an improved screw cutter. We have seen the machine in operation, and from its power it is capable of cutting an iron screw in a very short time. The machine promises to be of general utility.

Dr. Mease observes, that Mr. Voight, chief coiner in the mint of the United States, has invented an engine for turning screws of any given diameter, and of any number of threads, to an inch. This invention was first designed for cutting fusees for watches, so as uniformly to adjust them to the length of the main-spring, a thing hitherto very difficult in practice, and without which it is impossible a watch can keep regular time. By the aid of this machine a person of common mechanical abilities, and without any knowledge of mathematics, may adjust the fusee to the spring with the greatest exactness, or turn metallic cylinders and cones of any length or diameter, to a mathematical certainty.

We shall say something more on this subject under Mechanics.

A combination of the mechanical powers.—The following engine is very powerful, on account of its having the addition of four pullies; and in it we may look upon all the mechanical powers as combined together, even if we take in the balance. For, as the axle D of the bar AB enters its middle at C, No. 4, it is plain, that if equal weights be suspended upon any two pins equi-distant from the axis C, they will counterpoise each other. It becomes a lever by hanging a small weight P upon the pin *n*, and a weight as much heavier upon either of the pins *b*, *c*, *d*, *e*, or *f*, as is in proportion to the pins being so much nearer the axis. The wheel and axle FG is evident; so is the screw E which takes in the inclined plane, and with

it the half-wedge. Part of a cord goes round the axle, the rest under the lower pullies K, *m*, over the upper pullies L, *n*, and then it is tied to a hook at *m* in the lower or moveable block, on which the weight W hangs.



4.

In this machine, if the wheel F have 30 teeth, it will be turned once round in thirty revolutions of the bar AB, which is fixed on the axis D of the screw E: if the length of the bar be equal to twice the diameter of the wheel, the pins *a* and *n* at the ends of the bar will move 60 times as fast as the teeth of the wheel do; and consequently, one ounce at P will balance 60 ounces hung upon a tooth at *q* in the horizontal diameter of the wheel. Then, if the diameter of the wheel F be ten times as great as the diameter of the axle G, the wheel will have ten times the velocity of the axle; and therefore one ounce P at the end of the lever AC, will balance 10 times 60, or 600 ounces hung to the rope H which goes round the axle. Lastly, if four pullies be added, they will make the velocity of the lower block K, and weight W, four times less than the velocity of the axle: and this being the last power in the machine, which is four times as great as that gained by the axle, it makes the whole power of the machine 4 times 600, or 2400. So that a man who could lift one hundred weight in his arms by his natural strength, would be able to raise 2400 times as much by this engine. But it is here as in all other mechanical cases, that the time lost is always as much as the power gained, because the velocity with which the power moves will ever exceed the velocity with which the weight

rises, in proportion as the intensity of the weight exceeds the intensity of the power.

The friction of the screw itself is very considerable; and there are few compound engines but what, upon account of the friction of the parts against one another, will require a third part more of power to work them when loaded, than what is sufficient to constitute a balance between the weight and the power.

MECHANICS.—The following is the substance of a lecture on mills, cranes, and wheel-carriages, from Ferguson's Lectures.

Mill-work.—As these engines are so universally useful, it would be needless to make any apology for describing them.

Of various kinds of mills.—In a common breast-mill,* where the fall of water may be about ten feet, *AA* (Plate III. Fig. 2.) is the great wheel, which is generally about 17 or 18 feet in diameter, reckoned from the outermost edge of any float-board at *a* to that of its opposite float at *b*. To this wheel the water is conveyed through a channel, and, by falling upon the wheel, turns it round

On the axis *BB* of this wheel, and within the mill-house, is a wheel *D*, about 8 or 9 feet diameter, having 61 cogs, which turn a trundle *E*, containing ten upright staves or rounds; and when these are the number of cogs and rounds, the trundle will make $6\frac{1}{10}$ revolutions for one revolution of the wheel.

The trundle is fixed upon a strong iron axis called the spindle, the lower end of which turns in a brass foot, fixed at *F*, in the horizontal beam *ST* called the bridge-tree; and the upper part of the spindle turns in a wooden bush fixed into the nether millstone which lies upon beams in the floor *YY*. The top part of the spindle above the bush is square, and goes into a square hole in a strong iron cross *abcd* (see Fig. 3.) called the rynd; under which, and close to the bush, is a round piece of thick leather upon the spindle, which it turns round at the same time as it does the rynd.

The rynd is let into grooves in the under surface of the running millstone *G*, (Fig. 2.) and so turns it round in the same time that the trundle *E* is turned round by the cog-wheel *D*.† This millstone has a large hole quite through its middle, called the eye of the stone, through which the middle part of the rynd and upper end of the spindle may be seen, while the four ends of the rynd lie hid below the stone in their grooves.

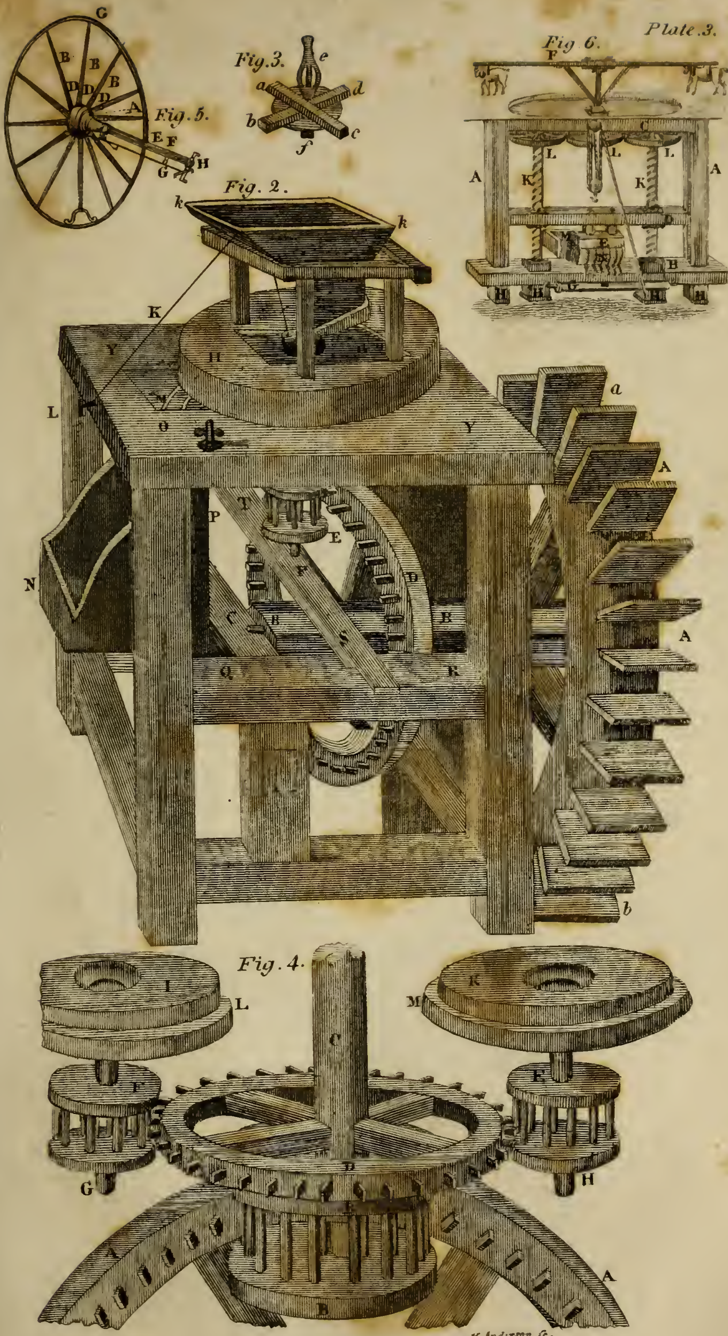
The end *T* of a bridge-tree *TS* (which supports the upper millstone *G* upon the spindle) is fixed into a hole in the wall; and the end *S* is let into a beam *QR* called the brayer, whose end *R* remains fixed in a mortise; and its other end *Q* hangs by a strong iron rod *P*, which goes through the floor *YY*, and has a screw-nut on its top at *O*; by the turning of which nut, the end *Q* of the brayer is raised or depressed at pleasure; and, consequently, the bridge-tree *TS* and upper millstone. By this means, the upper millstone may be set as close to the under one, or raised as high from it, as the miller pleases. The nearer the millstones are to one another, the finer they grind the corn, and the more remote from one another, the coarser.

The upper millstone *G* is inclosed in a round box *H*, which does not touch it any where; and is about an inch distant from its edge all around. On the top of this box stands a frame for holding the hopper *kk*, to which is hung the shoe *I* by two lines fastened to the hind-part of it, fixed upon hooks in the hopper, and by one end

* Water mills are divided into *breast-mills*, *undershot-mills*, and *overshot-mills*. In breast-mills, the water falls at right angles upon the float-boards or buckets, placed upon the circumference of the wheel When float-boards are used, the water acts by its impulse; but, when buckets are employed, both the weight and impulse of the water are concerned in turning the wheel. In undershot-mills, float-boards only are employed; and the motion of the wheel affected merely by the force of the stream, which strikes the boards below the wheel's centre. In overshot-mills, buckets only are used, and the wheel is turned chiefly by the weight of the water which is poured over its top into the buckets. An undershot-mill requires the greatest quantity of water; and an overshot-mill the least. It has long been disputed among mechanical philosophers, whether overshot or undershot-mills produce the greatest effect. M. Belidor (*Architecture Hydraulique*) maintained, that undershot-mills were greatly superior to the other kind; while Dr Desaguliers held a contrary opinion. It appears, however, from the accurate experiments of Mr. Smeaton, that in undershot-mills the power is to the effect as 3 to 1, and in overshot-mills as 3 to 2, or rather as 5 to 4.

† A considerable quantity of friction might be removed by making the staves or rounds of the trundle *E*, move on spindles of iron or brass, fixed to the end-boards.

Plate. 3.



of the crook-string *K* fastened to the fore part of it at *i*; the other end being twisted round the pin *L*. As the pin is turned one way, the string draws up the shoe closer to the hopper, and so lessens the aperture between them; and as the pin is turned the other way, it lets down the shoe, and enlarges the aperture.

If the shoe be drawn up quite to the hopper, no corn can fall from the hopper into the mill; if it be let a little down, some will fall; and the quantity will be more or less, according as the shoe is more or less let down. For the hopper is open at bottom, and there is a hole in the bottom of the shoe, not directly under the bottom of the hopper, but forwarder toward the end *i*, over the middle of the eye of the millstone.

There is a square hole in the top of the spindle, in which is put the feeder *e*; (Fig. 3.) this feeder (as the spindle turns round) jogs the shoe three times in each revolution, and so causes the corn to run constantly down from the hopper through the shoe, into the eye of the millstone, where it falls upon the top of the rynd, and is, by the motion of the rynd, and the leather under it, thrown below the upper stone, and ground between it and the lower one. The violent motion of the stone creates a centrifugal force in the corn going round with it, by which means it gets farther and farther from the centre, as in a spiral, in every revolution, until it be thrown quite off; and being then ground, it falls through a spout *M*, called the mill-eye, into the trough *N*

When the mill is fed too fast, the corn bears up the stone, and is ground too coarse; and besides, it clogs the mill so as to make it go too slow. When the mill is too slowly fed, it goes too fast, and the stones by their attrition against one another, are apt to strike fire. Both which inconveniences are avoided by turning the pin *L* backward or forward, which draws or lets down the shoe; and so regulates the feeding as the miller sees convenient.

The heavier the running millstone is, and the greater the quantity of water that falls upon the wheel, so much the faster will the mill bear to be fed; and consequently so much the more it will grind: and, on the contrary, the lighter the stone, and the less the quantity of water, so much slower must the feeding be. But when the stone is considerably worn, and become light, the mill must be fed slowly at any rate; otherwise the stone will be too much borne up by the corn under it, which will make the meal coarse.

The quantity of power required to turn a heavy millstone is but very little more than what is sufficient to turn a light one; for as it is supported upon the spindle by the bridgetree *ST*, and the end of the spindle that turns in the brass foot therein being but small, the odds arising from the weight is but very inconsiderable in its action against the power or force of the water: and, besides, a heavy stone has the same advantage as a heavy fly; namely, that it regulates the motion much better than a light one.

In order to cut and grind the corn, both the upper and under millstones have channels or furrows cut into them, proceeding obliquely from the centre toward the circumference: and these furrows are cut perpendicularly on one side, and obliquely on the other into the stone, which gives each furrow a sharp edge, and in the two stones they come, as it were, against one another, like the edges of a pair of scissors; and so cut the corn, to make it grind the easier when it falls upon the places between the furrows. These are cut the same way in both stones when they lie upon their backs, which makes them run crosswise to each other when the upper stone is inverted by turning its furrowed surface toward that of the lower. For, if the furrows of both stones lay the same way, a great deal of the corn would be driven onward in the lower furrows, and so come out from between the stones without being either cut or bruised.

When the furrows become blunt and shallow by wearing, the running stone must be taken up, and both stones new dressed with a chisel and hammer; and every time the stone is taken up, there must be some tallow put round the spindle upon the bush, which will soon be melted by the heat the spindle acquires from its turning and rubbing against the bush, and so will get in between them, otherwise the bush would take fire in a very little time.

The bush must embrace the spindle quite close, to prevent any shake in the motion, which would make some parts of the stones grate and fire against each other, while other parts of them would be too far asunder, and by that means spoil the meal in grinding.

Whenever the spindle wears the bush so as to begin to shake in it, the stone must be taken up, and a chisel driven into several parts of the bush; and when it is taken out, wooden wedges must be driven into the holes: by which means the bush will be made to embrace the spindle close all around it again. In doing this, great care must be taken to drive equal wedges into the bush on opposite sides of

the spindle, otherwise it will be thrown out of the perpendicular, and so hinder the upper stone from being set parallel to the under one, which is absolutely necessary for making good work. When any accident of this kind happens, the perpendicular position of the spindle must be restored by adjusting the bridge-tree ST by proper wedges put between it and the brayer QR.

It often happens that the rynd is a little wrenched in laying down the upper stone upon it, or is made to sink a little lower upon one side of the spindle than on the other; and this will cause one edge of the upper stone to drag all around upon the other, while the opposite edge will not touch. But this is easily set to rights, by raising the stone a little with a lever, and putting bits of paper, cards, or thin chips between the rynd and the stone.

The diameter of the upper stone is generally about six feet, the lower stone about an inch more; and the upper stone, when new, contains about $22\frac{1}{2}$ cubic feet, which weighs somewhat more than 1,900 pounds. A stone of this diameter ought never to go more than 60 times round in a minute; for, if it turn faster, it will heat the meal.

The grinding surface of the under stone is a little convex from the edge to the centre, and that of the upper stone a little more concave: so that they are farthest from one another in the middle, and come gradually nearer toward the edges. By this means, the corn at its first entrance between the stones is only bruised; but as it goes farther on toward the circumference or edge, it is cut smaller and smaller; and at last finely ground just before it comes out from between them.

The water-wheel must not be too large; for, if it be, its motion will be too slow; nor too little, for then it will want power. And for a mill to be in perfection, the floats of the wheel ought to move with a third part of the velocity of the water, and the stone to turn round once in a second of time.

In order to construct a mill in this perfect manner, observe the following rules:

1. Measure the perpendicular height of the fall of water, in feet, above that part of the wheel on which the water begins to act; and call that the height of the fall.

2. Multiply this constant number 64,2882 by the height of the fall in feet, and the square root of the product will be the velocity of the water at the bottom of the fall, or the number of feet that the water there moves per second.

3. Divide the velocity of the water by 3, and the quotient will be the velocity of the float-boards of the wheel, or the number of feet they must each go through in a second, when the water acts upon them, so as to have the greatest power to turn the mill.

4. Divide the circumference of the wheel in feet, by the velocity of its floats in feet per second, and the quotient will be the number of seconds in which the wheel turns round.

5 By this last number of seconds divide 60; and the quotient will be the number of turns of the wheel in a minute.

6. Divide 60 (the number of revolutions the millstone ought to have in a minute) by the number of turns of the wheel in a minute, and the quotient will be the number of turns the millstone ought to have for one turn of the wheel.

7. Then, as the number of turns of the wheel in a minute is to the number of turns of the millstone in a minute, so must the number of staves in the trundle be to the number of cogs in the wheel, in the nearest whole numbers that can be found.

By these rules has been calculated the following table to the water-wheel 18 feet diameter, which it is apprehended may be a good size in general.

To construct a mill by this table, find the height of the fall of water in the first column, and against that height, in the sixth column, you have a number of cogs in the wheel, and staves in the trundle, for causing the millstone to make about 60 revolutions in a minute, as near as possible, when the wheel goes with a third part of the velocity of the water: and it appears by the seventh column, that the number of cogs in the wheel, and staves in the trundle, are so near the truth for the required purpose, that the least number of revolutions of the millstone in a minute is between 59 and 60, and the greatest number never amounts to 61.

THE MILL-WRIGHT'S TABLE.

Height of the fall of water.	Velocity of the water per second	Velocity of the wheel per second.	Revolutions of the wheel per minute.	Revolutions of the mill-stone for one of the wheel.	Cogs in the wheel and staves in the trundle.		Rev. of the mill-stone per min. by these staves & cogs.
Feet.	Feet. 100 parts of a foot.	Feet. 100 parts of a foot.	Rev. 100 parts of a rev.	Rev. 100 parts of a rev.	Cogs.	Staves.	Rev. 100 parts of a rev.
1	8.02	2.67	2.83	21.20	127	6	59.92
2	11.34	3.78	4.00	15.00	105	7	60.00
3	13.89	4.63	4.91	12.22	98	8	60.14
4	16.04	5.35	5.67	10.58	95	9	59.87
5	17.93	5.98	6.34	9.46	85	9	59.84
6	19.64	6.55	6.94	8.64	78	9	60.10
7	21.21	7.07	7.50	8.00	72	9	60.00
8	22.68	7.56	8.02	7.48	67	9	59.67
9	24.05	8.02	8.51	7.05	70	10	59.57
10	25.35	8.45	8.97	6.69	67	10	60.09
11	26.59	8.86	9.40	6.38	64	10	60.16
12	27.77	9.26	9.82	6.11	61	10	59.90
13	28.91	9.64	10.22	5.87	59	10	60.18
14	30.00	10.00	10.60	5.66	56	10	59.36
15	31.05	10.35	10.99	5.46	55	10	60.48
16	32.07	10.69	11.34	5.29	53	10	60.10
17	33.06	11.02	11.70	5.13	51	10	59.67
18	34.02	11.34	12.02	4.99	50	10	60.10
19	34.95	11.65	12.37	4.85	49	10	60.61
20	35.86	11.95	12.68	4.73	47	10	59.59
1	2	3	4	5	6		7

Such a mill as this, with a fall of water about 7½ feet, will require about 32 hogsheads every minute to turn the wheel with a third part of the velocity with which the water falls; and to overcome the resistance arising from the friction of the gears, and attrition of the stones in grinding the corn.

The greater fall the water has, the less quantity of it will serve to turn the mill. The water is kept up in the mill-dam, and let out by a sluice called the penstock, when the mill is to go. When the penstock is drawn up by means of a lever, it opens a passage through which the water flows to the wheel; and when the mill is to be stopt, the penstock is to be let down, which stops the water from falling upon the wheel.

A less quantity of water will turn an over-shot mill (where the wheel has buckets instead of floatboards) than a breast-mill, where the fall of the water seldom exceeds half the height *A b* of the wheel: so that, where there is but a small quantity of water, and a fall great enough for the wheel to lie under it, the bucket or overshot-wheel is always used. But where there is a large body of water, with a little fall, the breast or floatboard wheel must take place. Where the water runs only upon a little declivity, it can act but slowly upon the under part of the wheel at *b*; in which case, the motion of the wheel will be very slow, and therefore, the floats ought to be very long, though not high, that a large body of water may act upon them; so that what is wanting

in velocity may be made up in power; and then the cog-wheel may have a greater number of cogs in proportion to the rounds in the trundle, in order to give the millstone a sufficient degree of velocity.

They who have read what is said concerning the acceleration of bodies falling freely by the power of gravity acting constantly and uniformly upon them, may perhaps ask, Why should the motion of the wheel be equable, and not accelerated, seeing the water acts constantly and uniformly upon it? The plain answer is, That the velocity of the wheel can never be so great as the velocity of the water that turns it; for if it should become so great, the power of the water would be quite lost upon the wheel, and then there would be no proper force to overcome the friction of the gears and attrition of the stones. Therefore, the velocity with which the wheel begins to move, will increase no longer than till its *momentum* or force is balanced by the resistance of the working parts of the mill: and then the wheel will go on with an equable motion.*

If the cog-wheel *D* be made about 18 inches diameter, with 30 cogs, the trundle as small in proportion, with 10 staves, and the millstones be each about two feet in diameter, and the whole work be put into a strong frame of wood, as represented in the figure, the engine will be a hand-mill for grinding corn or malt in private families: and then, it may be turned by a winch instead of the wheel *A A*; the millstone making three revolutions for every one of the winch. If a heavy fly be put upon the axle *B*, near the winch, it will help to regulate the motion.†

If the cogs of the wheel and rounds of the trundle could be put in as exactly as the teeth are cut in the wheels and pinions of a clock, then the trundle might divide the wheel exactly; that is to say, the trundle might make a given number of revolutions for one of the wheel, without a fraction. But as any exact number is not necessary in mill-work, and the cogs and rounds cannot be set in so truly as to make all the intervals between them equal, a skilful mill-wright will always give the wheel what he calls a *hunting cog*; that is, one more than what will answer to an exact division of the wheel by the trundle. And then, as every cog comes to the trundle, it will take the next staff or round behind the one which it took in the former revolution; and by that means will wear all the parts of the cogs and rounds which work upon one another equally, and to equal distances from one another in a little time; and so make a true uniform motion throughout the whole work. Thus, in the above water-mill, the trundle has 10 staves, and the wheel 61 cogs.

Sometimes, where there is a sufficient quantity of water, the cog-wheel *A A*, Fig. 4. No 1. turns a large trundle *B B*, on whose axis *C* is fixed the horizontal wheel *D*, with cogs all around its edge, turning two trundles *E* and *F* at the same time; whose axes or spindles *G* and *H* turn two mill-stones *I* and *K*, upon the fixed stones *L* and *M*. And when there is not work for them both, either may be made to lie quiet, by taking out one of the staves in its trundle, and turning the vacant place toward the cog-wheel *D*: also, there may be a wheel fixed on the upper end of the great upright axle *C*, for turning a couple of boulting-mills, and other work; for drawing up the sacks, fanning and cleaning the corn, sharpening of tools, &c.

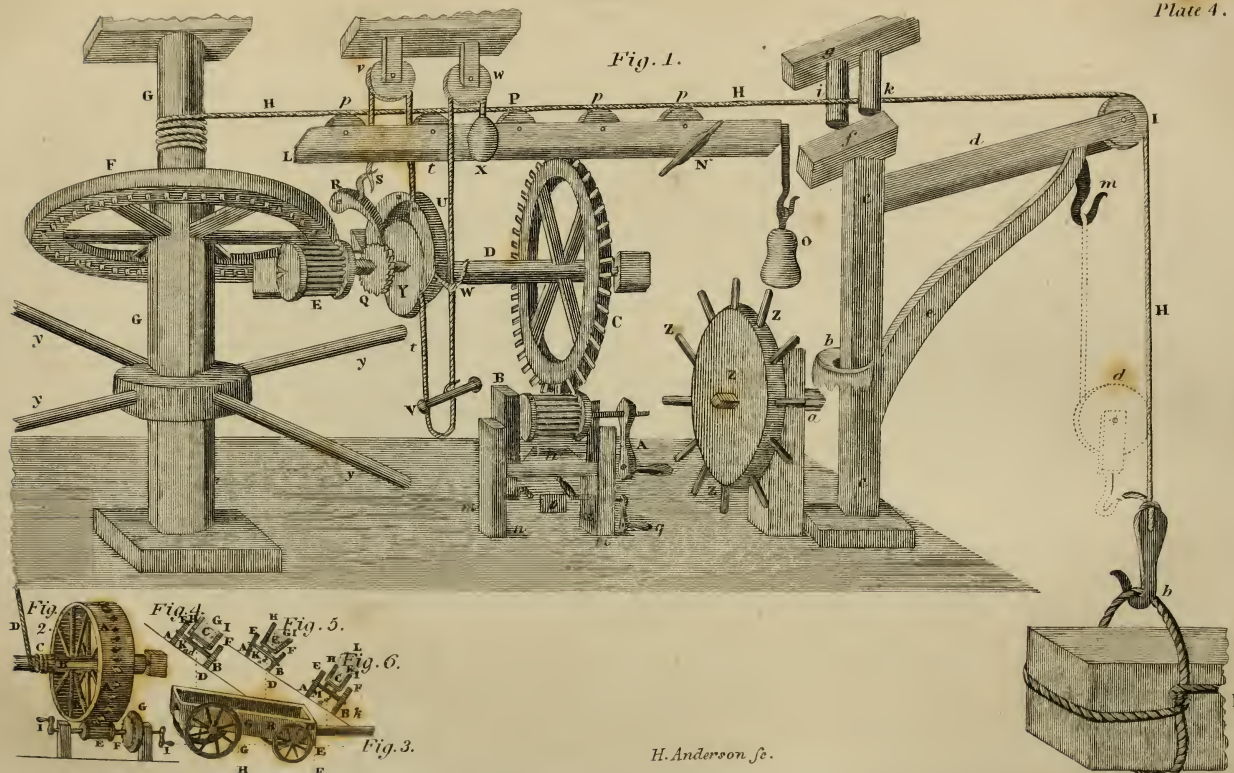
If, instead of the cog-wheel *A A*, and trundle *B B*, horizontal levers be fixed into the axle *C*, below the wheel *D*, then horses may be put to these levers for

* The author's explanation of this remarkable fact, viz. that the best constructed machines acquire in a short time a uniform motion, is far from being satisfactory.—The question indeed, is extremely difficult; and from our imperfect knowledge of the nature of friction, it does not admit of a scientific explanation. When a pendulum-clock is stripped of its pallets, and allowed to run down, it acquires a uniform motion in a very short time, though there is little friction, and though the moving power acts with the greatest uniformity. Dr. Robison observes, that the "uniform motion of machines arises from a diminution of the impelling power by an increase of velocity; but that there is something yet unexplained in the nature of friction, which takes away some of the acceleration."

† If the fly be put upon the axle *B*, its velocity will not be sufficient to make it of any use as a regulator. In an ingenious hand-mill, invented by Mr Lloyd, this defect is remedied by fixing a hollow circular fly upon the upper millstone, with iron straps. Its diameter is two feet, the breadth of its rim three inches and a half, and its depth five inches. It is divided into six cavities, into which a quantity of lead shot is put to bring it to a proper weight. For this invention Mr. Lloyd was rewarded with fifty pounds. A drawing and description of it may be seen in Bailey's Designs of Machines, approved and adopted by the Society of Arts, vol. 1, p. 176; and vol. 2. 44.

Cranes.

Plate 4.



H. Anderson sc.

turning the mill; which is often done where water cannot be had for that purpose

The working parts of a wind-mill differ very little from those of a water-mill; only the former is turned by the action of the wind upon four sails, every one of which ought (as is generally believed) to make an angle of 54¾ degrees, with a plane perpendicular to the axis on which the arms are fixed for carrying them. It being demonstrable, that when the sails are set to such an angle, and the axis turned endwise toward the wind, the wind has the greatest power upon the sails. But this angle answers only to the case of a vane or sail just beginning to move: [*Note.* See Maclaurin's Fluxions, near the end.] for, when the vane has a certain degree of motion, it yields to the wind; and then that angle must be increased to give the wind its full effect.

Again, the increase of this angle should be different, according to the different velocities from the axis to the extremity of the vane. At the axis it should be 54¾ degrees, and thence continually decrease, giving the vane a twist, and so causing all the ribs of the vane to lie in different planes.

Lastly, these ribs ought to decrease in length from the axis to the extremity, giving the vane a curvilineal form; so that no part of the force of any one rib is spent upon the rest, but all move on independent of each other. All this is required to give the sails of a wind-mill their true form; and we see both the twist and the diminution of the ribs exemplified in the wings of birds.

It is almost incredible to think with what velocity the tips of the sails move when acted upon by a moderate gale of wind. I have several times counted the number of revolutions made by the sails in ten or fifteen minutes; and from the length of the arms from tip to tip, have computed, that if a hoop of that diameter was to run upon the ground with the same velocity it would have if put upon the sail-arms, it would go upwards of 30 miles in an hour.

As the ends of the sails nearest the axis cannot move with the same velocity that the tips or farthest ends do, although the wind acts equally strong upon them, perhaps a better position than that of stretching them along the arms directly upon the centre of motion, might be to have them set perpendicularly across the farther ends of the arms, and there adjusted lengthwise to the proper angle. For, in that case, both ends of the sails would move with the same velocity; and being farther from the centre of motion, they would have so much the more power: and then there would be no occasion for having them so large as they are generally made; which would render them lighter, and consequently there would be so much the less friction on the thick neck of the axle where it turns in the wall. [*Note* A description of an improved wind-mill, and an account of Smeaton and Coulomb's improvements, may be seen in vol. 2d. of Ferguson's lectures.]

Of the Crane—A *crane* is an engine by which great weights are raised to certain heights, or let down to certain depths. It consists of wheels, axles, pulleys, ropes, and a gib or gibbet When the rope *H*, Fig. 1, Plate 4, is hooked to the weight *K*, a man turns the winch *A*, on the axis whereof is the trundle *B*, which turns the wheel *C*, on whose axis *D* is the trundle *E*, which turns the wheel *F* with its upright axis *G*, on which the great rope *HH* winds as the wheel turns; and going over a pulley *I* at the end of the arm *d* of the gib *c c d e*, it draws up the heavy weight *K*; which, being raised to a proper height, as from a ship to the quay, is then brought over the quay by pulling the wheel Z round by the handles *z*, *z*, which turns the gib by means of the half-wheel *b* fixed on the gib-post *c c*, and the strong pinion *a* fixed on the axis of the wheel Z. This wheel gives the man that turns it an absolute command over the gib, so as to prevent it from taking an unlucky swing, such as often happens when it is only guided by a rope tied to its arm *d*; and people are frequently hurt, sometimes killed, by such accidents.

The great rope goes between two upright rollers *i* and *k*, which turn upon gudgeons in the fixed beams *f* and *g*; and as the gib is turned toward either side, the rope bends upon the roller next that side. Were it not for these rollers, the gib would be quite unmanageable; for the moment it were turned ever so little toward any side, the weight *K* would begin to descend, because the rope would be shortened between the pulley *I* and axis *G*; and so the gib would be pulled violently to that side, and either be broken to pieces, or break every thing that came in its way. These rollers must be so placed, that the sides of them, round which the rope bends, may keep the middle of the bended part directly even with the centre of the hole in which the upper gudgeon of the gib turns in the beam *f*. The truer these rollers are placed, the easier the gib is managed, and the less apt to swing

either way by the force of the weight *K*.

A ratchet-wheel *Q* is fixed upon the axis *D*, near the trundle *E*; and into this wheel the catch or click *R* falls. This hinders the machinery from running back by the weight of the burden *K*, if the man who raises it should happen to be careless, and so leave off working at the winch *A* sooner than he ought to do.

When the weight *K* is raised to its proper height from the ship, and brought over the quay by turning the gib about, it is let down gently upon the quay, or into a cart standing thereon, in the following manner:—A man takes hold of the rope *t t* (which goes over the pulley *v*, and is tied to a hook at *S* in the catch *R*) and so disengages the catch from the ratchet-wheel *Q*; and then the man at the winch *A* turns it backward, and lets down the weight *K*. But when the weight pulls too hard against this man, another lays hold of the stick *V*, and by pulling it downward, draws the gripe *U* close to the wheel *Y*, which, by rubbing hard against the gripe, hinders the too quick descent of the weight: and not only so, but even stops it any time, if required. By this means, heavy goods may be either raised or let down at pleasure, without any danger of hurting the men who work the engine.

When part of the goods is craned up, and the rope is to be let down for more, the catch *R* is first disengaged from the ratchet-wheel *Q*, by pulling the cord *t*; then the handle *q* is turned half round backward, which by the crank *n n* in the piece *o*, pulls down the frame *h* between the guides *m* and *m* (in which it slides in a groove) and so disengages the trundle *B* from the wheel *C*: and then the heavy hook *b* at the end of the rope *H* descends by its own weight, and turns back the great wheel *F* with its trundle *E*, and the wheel *C*; and this last wheel acts like a fly against the wheel *F* and hook *b*, and so hinders it from going down too quick; while the weight *X* keeps up the gripe *U* from rubbing against the wheel *Y*, by means of a cord going from the weight, over the pulley *w* to the hook *W* in the gripe; so that the gripe never touches the wheel, unless it be pulled down by the handle *V*.

When the crane is to be set at work again, for drawing up another burden, the handle *q* is turned half round forward; which by the crank *n n*, raises up the frame *h*, and causes the trundle *B* to lay hold of the wheel *C*; and then, by turning the winch *A*, the burden of goods *K* is drawn up as before.

The crank *n n* turns pretty stiff in the mortice near *o*, and stops against the farther end of it when it has got just a little beyond the perpendicular; so that it can never come back of itself: and therefore, the trundle *B* can never come away from the wheel *C*, until the handle *q* be turned half round backward.

The great rope runs upon rollers in the lever *LM*, which keeps it from bending between the axle at *G* and the pulley *I*. This lever turns upon the axis *N*, by means of the weight *O*, which is just sufficient to keep its end *L* up to the rope; so that, as the great axle turns, and the rope coils round it, the lever rises with the rope, and prevents the coilings from going over one another.

The power of this crane may be estimated thus:—suppose the trundle *B* to have 13 staves or rounds, and the wheel *C* to have 78 spurcogs; the trundle *E* to have 14 staves, and the wheel *F* 56 cogs. Then, by multiplying the staves of the trundles, 13 and 14, into one another, their product will be 182: and by multiplying the cogs of the wheels, 78 and 56, into one another, their product will be 4368, and dividing 4368 by 182, the quotient will be 24; which shows that the winch *A* makes 24 turns for one turn of the wheel *F* and its axle *G*, on which the great rope or chain *H I H* winds. So that, if the length or radius of the winch *A* were only equal to half the diameter of the great axle *G*, added to half the thickness of the rope *H*, the power of the crane would be as 24 to 1; but the radius of the winch being double the above length, it doubles the said power, and so makes it as 48 to 1; in which case, a man may raise 48 times as much weight by this engine as he could do by his natural strength without it, making proper allowance for the friction of the working parts.—Two men may work at once, by having another winch on the opposite end of the axis of the trundle under *B*; and this will make the power double.

If this power be thought greater than what may be generally wanted, the wheels may be made with fewer cogs in proportion to the staves in the trundles; and so the power may be of whatever degree is judged to be requisite. But if the weight be so great as will yet require more power to raise it, suppose a double quantity, then the rope *H* may be put under a moveable pulley, as *d*, and the end of it tied to a hook in the gib at *m*; which will give a double power to the machine, and so raise a double weight hooked to the block of the moveable pulley.

When only small burdens are to be rais-

ed, this may be quickly done by men pushing the axle *G* round the long spokes *y, y, y, y;* having first disengaged the trundle *B* from the wheel *C:* and then, this wheel will only act as a fly upon the wheel *F;* and the catch *R* will prevent its running back, if the men should inadvertently leave off pushing before the burden be unhooked from *b*.

Lastly, when very heavy burdens are to be raised, which might endanger the breaking of the cogs in the wheel *F;* their force against these cogs may be much abated by men pushing round the long spokes *y, y, y, y,* while the man at *A* turns the winch.

I have only shown the working parts of this crane, without the whole of the beams which support them; knowing that these are easily supposed, and that if they had been drawn, they would have hid a great deal of the working parts from sight, and also confused the figure.

Another very good *crane* is made in the following manner.—*A A* (Plate IV. Fig. 2) is a great wheel turned by men walking within it at *H*. On the part *C*, of its axle *BC*, the great rope *D* is wound as the wheel turns; and this rope draws up goods in the same way as the rope *H h* does in the above-mentioned crane, the gib-work here being supposed to be of the same sort. But these cranes are very dangerous to the men in the wheel; for, if any of the men should chance to fall, the burden will make the wheel run back, and throw them all about within it; which often breaks their limbs, and sometimes kills them, The late ingenious Mr. Padmore, of Bristol (whose contrivance the fore-mentioned crane is) observing this dangerous construction, contrived a method of remedying it, by putting cogs all around the outside of the wheel, and applying a trundle *E* to turn it; which increases the power as much as the number of cogs in the wheel is greater than the number of staves in the trundle; and by putting a ratchet-wheel *F* on the axis of the trundle (as in the above-mentioned crane) with a catch to fall into it, the great wheel is stopt from running back by the force of the weight, even if all the men in it should leave off walking: and by one man working at the winch *I*, or two men at the opposite winches when needful, the men in the wheel are much assisted, and much greater weights are raised, than could be done by men only within the wheel. Mr. Padmore put also a gripe-wheel *G* upon the axis of the trundle, which being pinched in the same manner as described in the former crane, heavy burdens may be let down without the least danger. And before this contrivance, the lowering of goods was always attended with the utmost danger to the men in the wheel; as every one must be sensible of, who has seen such engines at work.

And it is surprising that the masters of wharves and cranes should be so regardless of the limbs, or even lives, of their workmen, that, excepting the late Sir James Creed, of Greenwich, and some gentlemen at Bristol, there is scarce an instance of any one who has used this safe contrivance.*

A description of a new and safe Crane, which has four different powers, adapted to different weights.—By Mr. Brewster.

The common crane consists only of a large wheel and axle; and the rope, by which goods are drawn up from ships, or let down to them from the quay, winds or coils round the axle, as the axle is turned by men walking in the wheel. But, as these engines have nothing to stop the weight from running down, if any of the men happen to trip or fall in the wheel, the weight descends, and turning the wheel rapidly backward, tosses the men violently about within it; which has produced melancholy instances, not only of limbs broken, but even of lives lost, by this ill-judged construction of cranes. And besides, they have but one power for all sorts of weights; so that they generally spend as much time in raising a small weight as in raising a great one.

These imperfections and dangers induced me to think of a method for remedying them. And for that purpose, I contrived a crane with a proper stop to prevent the danger, and with different powers suited to different weights; so that there might be as little loss of time as possible: and also, that when heavy goods are let down into ships, the descent may be regular and deliberate.

This crane has four different powers:

* An improved crane for wharves has lately been invented by Mr. Robert Hall, of Basford, in Great Britain, who was rewarded with forty guineas by the Society of Arts. The invention chiefly consists in expanding a set of bars parallel to the axis of a crane, by means of which, the velocity of the rope in raising weights may be diminished or increased, in proportion to the load which is to be raised. An engraving and description of this crane may be seen in the Transactions of the Society for the encouragement of Arts, vol. 12; or in the Philosoph. Mag. April, 1804, p. 270.

and, I believe, might be built in a room 8 feet in width: the gib being on the outside of the room.

Three trundles, with different numbers of staves, are applied to the cogs of an horizontal wheel with an upright axle; and the rope that draws up the weight coils round the axle. The wheel has ninety-six cogs, the largest trundle twenty-four staves, the next largest has twelve, and the smallest has six. So that the largest trundle makes four revolutions for one revolution of the wheel: the next makes eight, and the smallest makes sixteen. A winch is occasionally put upon the axis of either of these trundles, for turning it; that trundle being then used which gives a power best suited to the weight: and the handle of the winch describes a circle in every revolution equal to twice the circumference of the axle of the wheel. So that the length of the winch doubles the power gained by each trundle.

As the power gained by any machine or engine whatever, is in direct proportion as the velocity of the power is to the velocity of the weight; the powers of this crane are easily estimated, and are as follows.

If the winch be put upon the axle of the largest trundle, and turned four times round, the wheel and axle will be turned once round: and the circle described by the power that turns the winch, being, in each revolution, double the circumference of the axle, when the thickness of the rope is added thereto; the power goes through eight times as much space as the weight rises through: and therefore (making some allowance for friction) a man will raise eight times as much weight by this crane as he would by his natural strength without it: the power, in this case, being as eight to one.

If the winch be put upon the axis of the next trundle, the power will be as sixteen to one, because it moves sixteen times as fast as the weight moves.

If the winch be put upon the axis of the smallest trundle, and turned round, the power will be as thirty-two to one.

But if the weight should be too great, even for this power to raise, the power may be doubled by drawing up the weight by one of the parts of a double rope, going under a pulley in the moveable block, which is hooked to the weight below the arm of the gib; and then the power will be as sixty-four to one. That is, a man could then raise sixty-four times as much weight by the crane as he could raise by his natural strength without it; because, for every inch that the weight rises, the working power will move through sixty-four inches.

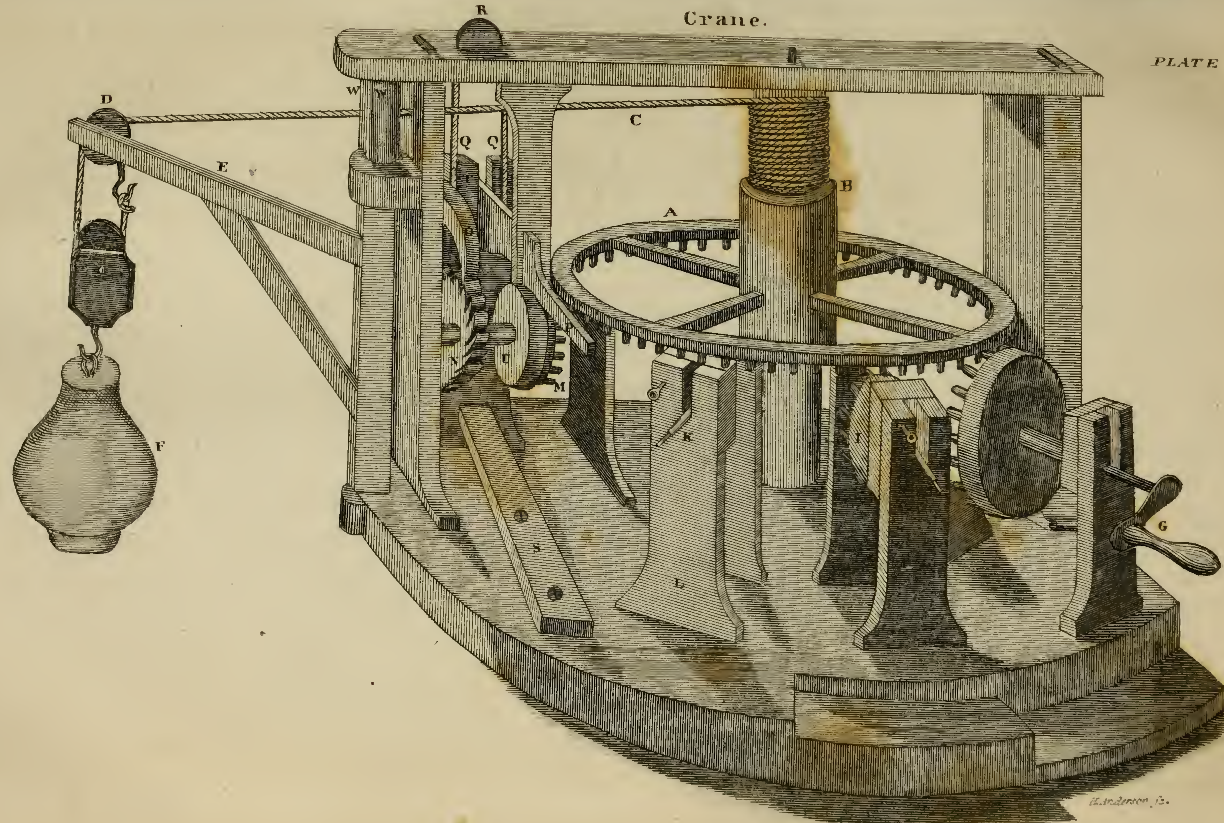
By hanging a block with two pullies to the arm of the gib, and having two pullies in the moveable block that rises with the weight, the rope being doubled over and under the pullies, the power of the crane will be as 128 to one. And thus, by increasing the number of pullies, the power may be increased as much as you please: always remembering, that the larger the pullies are, the less is their friction.

While the weight is drawing up, the ratch-teeth of a wheel slip round below a catch or click that falls successively into them, and so hinders the crane from turning backward, and detains the weight in any part of its ascent, if the man who works at the winch should accidentally happen to quit his hold, or choose to rest himself before the weight be quite drawn up.

In order to let down the weight, a man pulls down one end of a lever of the second kind, which lifts the catch of the ratchet-wheel, and gives the weight liberty to descend. But, if the descent be too quick, he pulls the lever a little farther down, so as to make it rub against the outer edge of a round wheel; by which means he lets down the weight as slowly as he pleases: and, by pulling a little harder, he may stop the weight, if needful, in any part of its descent. If he accidentally quits hold of the lever, the catch immediately falls, and stops both the weight and the whole machine.

This crane is represented in Plate 5, where A is the great wheel, and B its axle on which the rope C winds. This rope goes over a pulley D in the end of the arm of the gib E, and draws up the weight F, as the winch G is turned round. H is the largest trundle, I the next, and K is the axis of the smallest trundle, which is supposed to be hid from view by the upright supporter L. A trundle M is turned by the great wheel, and on the axis of this trundle is fixed the ratchet-wheel N, into the teeth of which the catch O falls. P is the lever, from which goes a rope QQ, over a pulley R to the catch; one end of the rope being fixed to the lever, and the other end to the catch. S is an elastic bar of wood, one end of which is screwed to the floor: and, from the other end goes a rope (out of sight in the figure) to the farther end of the lever, beyond the pin or axis on which it turns in the upright supporter T. The use of this bar is to keep up the lever from rubbing against the edge of the wheel U, and to let the catch keep in the teeth of the ratchet-wheel: but a weight hung to the farther end of the lever would do full as well as the elastic bar and rope.

Crane.



When the lever is pulled down, it lifts the catch out of the ratchet-wheel, by means of the rope QQ, and gives the weight F liberty to descend: but if the lever P be pulled a little farther down than what is sufficient to lift the catch O out of the ratchet-wheel N, it will rub against the edge of the wheel U, and thereby hinder the too-quick descent of the weight; and will quite stop the weight if pulled hard. And if the man who pulls the lever, should happen inadvertently to let it go, the elastic bar will suddenly pull it up and the catch will fall down and stop the machine.

WW are two upright rollers above the axis or upper gudgeon of the gib E: their use is to let the rope C bend upon them, as the gib is turned to either side, in order to bring the weight over the place where it is intended to be let down.

N. B. The rollers ought to be so placed, that if the rope C be stretched close by their utmost sides the half thickness of the rope may be perpendicularly over the centre of the upper gudgeon of the gib. For then, and in no other position of the rollers, the length of the rope between the pulley in the gib and the axle of the great wheel will be always the same, in all positions of the gib: and the gib will remain in any position to which it is turned.

When either of the trundles is not turned by the winch in working the crane, it may be drawn off from the wheel, after the pin near the axis of the trundle is drawn out, and the thick piece of wood is raised a little behind the outward supporter of the axis of the trundle. But this is not material; for, as the trundle has no friction on its axis but what is occasioned by its weight, it will be turned by the wheel without any sensible resistance in working the crane.

Of Wheel carriages.—The structure of *wheel-carriages* is generally so well known, that it would be needless to describe them; and therefore, we shall only point out some inconveniencies attending the common method of placing the wheels, and loading the waggons.

In coaches, and all other four-wheeled carriages, the fore-wheels are made of a less size than the hind ones, both on account of turning short, and to avoid cutting the braces; otherwise, the carriage would go much easier, if the fore-wheels were as high as the hind ones; and the higher the better, because they would sink to less depths in little hollowings in the roads, and be the more easily drawn out of them. But carriers and coachmen give another reason for making the fore-wheels much lower than the hind-wheels: merely, that when they are so, the hind-wheels help to push on the fore ones; which is too unphilosophical and absurd to deserve a refutation; and yet, for their satisfaction, we shall show by experiment that it has no existence but in their own imaginations.

It is plain that the small wheels must turn as much oftener round than the great ones, as their circumferences are less; and therefore, when the carriage is loaded equally heavy on both axles, the fore-axle must sustain as much more friction, and consequently wear out as much sooner, than the hind-axle, as the fore-wheels are less than the hind ones. But the great misfortune is, that all the carriers to a man do obstinately persist, against the clearest reason and demonstration, in putting the heavier part of the load upon the fore-axle of the waggon; which not only makes the friction greatest, where it ought to be least, but also presses the fore-wheels deeper into the ground than the hind-wheels, notwithstanding the fore-wheels, being less than the hind ones, are with so much the greater difficulty drawn out of a hole or over an obstacle, even supposing the weights on their axles were equal. For the difficulty, with equal weights, will be as the depth of the hole or height of the obstacle is to the semidiameter of the wheel. Thus, if we suppose the small wheel *D* (Fig. 3, Plate IV.) of the waggon *A B* to fall into a hole of the depth *E E*, which is equal to the semidiameter of the wheel, and the waggon to be drawn horizontally along, it is evident, that the point *E* of the small wheel will be drawn directly against the top of the hole; and therefore, all the power of horses and men will not be able to draw it out unless the ground gives way before it. Whereas, if the hind-wheel *G* fall into such a hole, it sinks not near so deep in proportion to its semidiameter; and therefore, the point *G* of the large wheel will not be drawn directly, but obliquely, against the top of the hole; and so will be easily got out of it Add to this, that as the small wheel will often sink to the bottom of a hole, in which a great wheel will go but a very little way, the small wheels ought in all reason to be loaded with less weight than the great ones; and then the heavier part of the load would be less jolted upward and downward, and the horses tired so much the less, as their draught raised the load to less heights.

It is true, that when the waggon-road is much up hill, there may be danger in loading the hind-part much heavier than the fore-part; for then the weight would

overhang the hind-axle, especially if the load be high, and endanger tilting up the fore-wheels from the ground. In this case, the safest way would be to load it equally heavy on both axles; and then, as much more of the weight would be thrown upon the hind-axle than the fore one, as the ground rises from a level below the carriage. But as this seldom happens, and when it does, a small temporary weight laid upon the pole between the horses would overbalance the danger; and this weight be thrown into the waggon when it comes to level ground; it is strange that an advantage so plain and obvious as would arise from loading the hind-wheels heaviest, should not be laid hold of, by complying with this method.

To confirm these reasonings by an experiment: let a small model of a waggon be made, with its fore-wheels $2\frac{1}{2}$ inches in diameter, and its hind-wheels $4\frac{1}{2}$; the whole model weighing about 20 ounces. Let this little carriage be loaded any how with weights, and have a small cord tied to each of its ends, equally high from the ground it rests upon; and let it be drawn along a horizontal board, first by a weight in a scale hung to the cord at the fore part; the cord going over a pulley at the end of the board, to facilitate the draught, and the weight just sufficient to draw it along. Then, turn the carriage, and hang the scale and weight to the hind-cord, and it will be found to move along with the same velocity as at first; which shows that the power required to draw the carriage is the same, whether the great or the small wheels be foremost; and therefore the great wheels do not help in the least to push on the small wheels in the road.

Hang the scale to the fore-cord, and place the fore-wheels (which are the small ones) in two holes, cut three-eighth parts of an inch deep into the board; and then put a weight of 32 ounces into the carriage, over the fore-axle, and an equal weight over the hind one: this done, put 44 ounces into the scale, which will be just sufficient to draw out the fore-wheels: but if this weight be taken out of the scale, and one of 16 ounces put into its place, if the hind-wheels be placed in the holes, the 16-ounce weight will draw them out; which is little more than a third part of what was necessary to draw out the fore-wheels. This shows, that the larger the wheels are, the less power will draw the carriage, especially on rough ground

Put 64 ounces over the axle of the hind-wheels, and 32 over the axle of the fore ones, in the carriage, and place the fore-wheels in the holes; then put 38 ounces into the scale, which will just draw out the fore-wheels; and when the hind ones come to the hole they will find but very little resistance, because they sink but a little way into it.

But shift the weights in the carriage, by putting the 32 ounces upon the hind-axle, and the 64 ounces upon the fore one, and place the fore-wheels in the holes: then, if 76 ounces be put into the scale, it will be found no more than sufficient to draw out these wheels This is double the power required to draw them out, when the lighter part of the load was put upon them: which is a plain demonstration of the absurdity of putting the heaviest part of the load in the fore part of the waggon.

Every one knows what an outcry was made by the generality, if not the whole body, of the carriers, against the broad-wheel act; and how hard it was to persuade them to comply with it, even though the government allowed them to draw with more horses, and carry greater loads, than usual. Their principal objection was, that as a broad wheel must touch the ground in a great many more points than a narrow wheel, the friction must of course be just so much the greater; and consequently, there must be so many more horses than usual to draw the waggon. I believe that the majority of the people were of the same opinion, not considering, that if the whole weight of the waggon and load in it bears upon a great many points, each sustains a proportionably less degree of weight and friction, than when it bears only upon a few points; so that what is wanting in one, is made up in the other; and therefore will be just equal under equal degrees of weight; as may be shown by the following plain and easy experiment.

Let one end of a piece of packthread be fastened to a brick, and the other end to a common scale for holding weights; then lay the brick edgewise on a table, and, letting the scale hang under the edge of the table, put as much weight into the scale as will just draw the brick along the table. Then taking back the brick to its former place, lay it flat on the table, and the same weight in the scale as before will draw it along with the same ease as when it lay upon its edge. In the former case, the brick may be considered as a narrow wheel on the ground; and in the latter, as a broad wheel. And since the brick is drawn along with equal ease, whether its broad side or narrow edge touches the table, it shows that a broad wheel might be drawn along the ground with the same ease as a narrow one (supposing them

equally heavy) even though they should drag, and not roll, as they go along.

As narrow wheels are always sinking in to the ground, especially when the heaviest part of the load lies upon them, they must be considered as going constantly up hill, even on level ground; and their sides must sustain a great deal of friction by rubbing against the ruts made by them But both these inconveniences are avoided by broad wheels; which, instead of cutting and ploughing up the roads, roll them smooth, and harden them, as experience testifies in places where they have been used, especially either on wettish or sandy ground; though after all it must be confessed, that they will not do in stiff clayey cross roads; because they would soon gather up as much clay as would be almost equal to the weight of an ordinary load.

If the wheels were always to go upon smooth and level ground, the best way would be to make the spokes perpendicular to the naves, that is, to stand at right angles to the axles; because they would then bear the weight of the load perpendicularly, which is the strongest way for wood. But because the ground is generally uneven, one wheel often falls into a cavity or rut when the other does not; and then it bears much more of the weight than the other does: in which case, concave or dishing wheels are best, because when one falls into a rut, and the other keeps upon high ground, the spokes become perpendicular in the rut, and therefore have the greatest strength when the obliquity of the load throws most of its weight upon them; while those on the high ground have less weight to bear, and therefore need not be at their full strength; so that the usual way of making the wheels concave is by much the best.

The axle of the wheels ought to be perfectly straight, that the rims of the wheels may be parallel to each other; for then they will move easiest, because they will be at liberty to go on straight forward. But in the usual way of practice, the axles are bent downward at their ends, which brings the edges of the wheels next the ground nearer to one another than their opposite or higher edges are: and this not only makes the wheels drag sidewise as they go along, and gives the load much greater power of crushing them than when they are parallel to each other; but also endangers the over-turning of the carriage when any wheel falls into a hole or rut; or when the carriage goes on a road which has one side lower than the other, as along the side of a hill. Thus (in the hind view of a waggon or cart) let *A E* and *B F* Fig. 4. be the great wheels parallel to each other, on their straight axle *K*, and *H C I* the carriage loaded with heavy goods from *C* to *G*. Then, as the carriage goes on in the oblique road *A a B*, the centre of gravity of the whole machine and load will be at *C*; and the line of direction *C d D* falling within the wheel *B F*, the carriage will not overset. But if the wheels be inclined to each other on the ground, as *A E* and *B F* are, Fig. 5. and the machine be loaded as before, from *C* to *G*, the line of direction *C d D* falls without the wheel *B F*, and the whole machine tumbles over. When it is loaded with heavy goods, (such as lead or iron) which lie low, it may travel safely upon an oblique road so long as the centre of gravity is at *C*, Fig. 4. and the line of direction *C d* falls within the wheels; but if it be loaded high with lighter goods (such as wool-packs) from *C* to *L*, Fig. 6. the centre of gravity is raised from C to *K*, which throws the line of direction *K k* without the lowest edge of the wheel *B F*, and then the load oversets the waggon.

If there be some advantage from small fore-wheels, on account of the carriage turning more easily and short than it can be made to do when they are large, there is at least as great a disadvantage attending them, which is, that as their axle is below the level of the horses' breast, the horses not only have the loaded carriage to draw along, but also part of its weight to bear, which tires them sooner, and makes them grow much stiffer in their hams, than they would do if they drew on a level with the fore-axle: and for this reason, we find coach-horses soon become unfit for riding. So that on all accounts it is plain, that the fore-wheels of all carriages ought to be so high, as to have their axles even with the breast of the horses; which would not only give the horses a fair draught, but likewise keep them longer fit for drawing the carriage.

Of Compound Machines.—If by any power you are able to raise a pound with a given velocity, it will be impossible, by the help of any machine, to raise two pounds with the same velocity; yet, by the assistance of a machine, you may raise two pounds with half that velocity, or even one thousand with the thousandth part of that velocity; but still there is no greater quantity of motion produced, when a thousand pounds are moved, than when one pound is moved; the thousand pounds moving proportionally slower.

No real gain of force is, therefore, obtained by mechanical contrivances; on the contrary, from friction and other cau-

ses, force is always lost; but by machines we are able to give a more convenient direction to the moving power, and to apply its action at some distance from the body to be moved, which is a circumstance of infinite importance. By machines also, we can so modify the energy of the moving power, as to obtain effects which it could not produce without this modification.

In machines composed of several of the mechanical powers, the power will be to the weight, when they are in equilibrio, in a proportion formed by the multiplication of the several proportions which the power bears to the weight in every separate mechanical power of which the machine consists.

Suppose a machine, for instance, composed of the axle in the wheel, and a pulley; let the axle and wheel be such, that a power consisting of one-sixth of the weight will balance it; and let the pullies be such, that by means of them alone, a power equal to one-fourth of the weight would support it: then, by means of the axle in the wheel, and the pullies combined, a power equal to one-fourth of one-sixth, that is, $\frac{1}{24}$ of the weight, will be in equilibrio with it.

In contriving machines, simplicity ought particularly to be attended to; for a complicated machine is not only more expensive, and more apt to be out of order, but there is also a greater degree of friction in proportion to the number of rubbing parts.

Whatever be the construction of a machine, its power will always be in proportion to the velocity of the power to the weight; and so that this is obtained in the greatest degree that circumstances will admit, or that are necessary, then the fewer parts the better

It is evident, from the principles already laid down, that the velocity of a wheel is to that of a pinion, or smaller wheel which is driven by it, in proportion to the diameter, circumference, or number of teeth in the pinion to that of the wheel. Thus, if the number of teeth in a wheel be 60, and those of the pinion 5, then the pinion will go 12 times round for once of the wheel, because 60, divided by 5, gives 12 for a quotient.

Hence, if you have any number of wheels acting on so many pinions, you must divide the product of the teeth in the wheels by those in the pinions; and the quotient will give the number of turns of the last pinion in one turn of the first wheel. Thus, if a wheel A (Fig. 1. Plate VIII.) of 48, acts on a pinion B of 8, on whose axis there is a wheel C of 40, driving a pinion D of 6, carrying a wheel E of 36, which moves a pinion F of 6, carrying an index; then the number of turns made by the index, will be found in this manner: $\frac{48}{8} \times \frac{40}{6} \times \frac{36}{6} = \frac{69120}{288} = 240$, the number of turns which the index will make while the wheel A goes once round.

Any number of teeth on the wheels and pinions having the same ratio, will give the same number of revolutions to an axis: thus, $\frac{64}{10} \times \frac{50}{8} \times \frac{36}{6} = \frac{115200}{480} = 240$, as before. It therefore depends upon the skill of the engineer, or mechanic, to determine what numbers will best suit his design.

It is evident, that the same motion may be performed, either by one wheel and pinion, or by many wheels and pinions, provided the number of turns of all the wheels bear the same proportion to all the pinions which that one wheel bears to its pinion.

When a wheel is moved immediately by the power, it is called a leader; and if there is another wheel on the same axis, it is called the follower. Thus A, being moved immediately by the power, is to be considered as a leader, and B as a follower; the wheel C being driven by B, becomes a leader, and D a follower; E (Fig. 2) is a leader, and the cylinder F may be considered as a follower.

Sometimes the same wheel acts both as a leader and a follower; as in Fig. 3, where B is moved by A, and consequently is a leader, while, as it drives C, it is also a follower. Therefore, as to multiply both the divisors and dividend by the same number, does not alter the quotient; in mechanical calculations, every wheel that is both a leader and a follower, may be entirely omitted.

The power of a machine is not at all altered by the size of the wheels, provided the proportions to each other are the same. Formerly the wheels of engines being mostly of wood, they were made of a large size, on account of strength; but now that cast-iron wheels are so easily made, and so much in use, the size of them is very much diminished, which has the advantage of occupying much less room.

Regulation of Motion by Fly-Wheels.— In all machines, the moving power acts with more or less irregularity, being sometimes stronger, and at other times weaker.

To correct this, and render the motion uniform, an additional part, called a fly, is applied, which is generally either a heavy wheel, or a cross bar loaded with equal weights. This, being made to re-

volve about its axis, keeps up the force of the power, and distributes it equally in all parts of its revolution; for on account of its weight, a small variation in force does not sensibly alter its motion; whilst friction, and the resistance of the machine, prevent it from accelerating. If the motion of the machine slackens, it helps it forward; if it tends to move too fast, it will keep it back.

Every regulating-wheel should be fixed upon that axis where the motion is swiftest, and should be heavy when the motion is designed to be slow, and light where it is designed to be swift. In all cases, the centre of motion should coincide with the centre of gravity of the wheel. The axis may be either perpendicular, or parallel to the horizon.

A small force is sufficient to put a heavy wheel in motion, which, if long continued, will accumulate in such a manner, as to produce effects in raising weights and overcoming resistances, which could not by any means be accomplished by the application of the original moving force.

On this subject, Mr. ATWOOD has demonstrated, that a force of 20 pounds applied for 37 seconds to the circumference of a cylinder of 10 feet radius, and weighing 4713 pounds, would, at the distance of one foot from the centre, give an impulse to a musket ball equivalent to what it receives from a full charge of gunpowder. The same effect would be produced in six minutes and ten seconds by a man turning the cylinder with a winch one foot long, in which he constantly exerted a force of 20 pounds. In this case, however, there is no absolute increase of power: for the cylinder has no principle of motion in itself, and cannot have more than it receives.

This accumulation of motion, however, in heavy wheels, is of great service in the construction of machines for various purposes, rendering them much more powerful, and easy to be worked by animals, as well as more regular and steady, when set in motion by water, or any inanimate power. Hence the use of flies, ballast-wheels, &c. which are commonly supposed to increase the power of a machine, though in reality they take something from it, and act upon a quite different principle.

In all machines in which flies are used, a considerably greater force must at first be applied than what is necessary to move the machine without it, or the fly must have been set in motion some time before it is applied to the machine. This superfluous power is collected by the fly, which serves as a kind of reservoir from whence the machine may be supplied when the motion slackens.

This, we must observe, will always be the case with machines worked by animals, for none are able to exert a great power with absolute constancy; some intervals of rest, even though almost imperceptible, are requisite, otherwise the creature's strength would in a short time be exhausted. When he begins to move in the machine, he is vigorous, and exerts a great power; in consequence of which he overcomes not only the resistance of the machine itself, but communicates a considerable degree of power to the fly. The machine, when moving, yields for a time to a smaller impulse; during which time the fly itself acts as a moving power, and the animal recovers the strength he has lost. By degrees, however, the motion of the machine decreases, and the animal is obliged to renew his efforts. The velocity of the machine would now be considerably increased, were it not that the fly now acts as a resisting power, and the greatest part of the superfluous motion is lodged in it, so that the increase of velocity is scarcely perceptible. Thus the animal has time to rest himself, until the machine again requires an increased impulse, and so on alternately.

The case is the same with a machine moved by water, or by a weight; for though the strength of these does not exhaust itself like that of an animal, yet the yielding of the parts of the machine renders the impulse much less after it begins to move; hence its velocity is accelerated for some time, until the impulse becomes so small, that the machine requires an increase of power to keep up the necessary motion. Then the machine slackens its pace, the water meets with more resistance, and of consequence exerts its power more fully, and the machine recovers its velocity.

But when a fly is added to the other parts, this acts first as a power of resistance, so that the machine does not acquire the velocity it would otherwise do. When it next begins to yield to the pressure of the water, and the impulse of course to slacken, the fly communicates part of its motion to the other parts; so that if the machine be well made, there is very little difference in the velocity perceptible.

The truth of what is here advanced will easily be seen, from considering the inequality of motion in a clock, when the pendulum is off, and how very regularly it goes when regulated by a pendulum, which here acts as a fly.

Flies are particularly useful in any kind of work which is done by alternate strokes, as the lifting of large pestles, pumping of water, &c. In this case, the weight of the wheel employed is a principal object; and the method of calculating this, is to compare it with the weight to be raised at each stroke of the machine. Thus, suppose it is required to raise a pestle 30 pounds weight to the height of one foot, 60 times in a minute; let the diameter of the fly be seven feet, and suppose the pestle to be lifted once at every revolution of the fly; we must then consider what weight passing through 22 feet in a second, will be equivalent to 30 pounds moving through one foot in a second. This will be 30 divided by 22, or $1\frac{4}{15}$ pounds. Were a fly of this kind to be applied, therefore, and the machine set a-going, the fly would just be able to lift the pestle once, after the moving power was withdrawn; but by increasing the weight of the fly to 10, 12, or 20 pounds, the machine, when left to itself, would make a considerable number of strokes, and be worked with much less labour than if no fly had been used, though, no doubt, at the first, it would be found a considerable incumbrance to the motion.

This is equally applicable to the action of pumps; but the weight which can be most advantageously given to a fly, has never yet been determined by mechanics. It is certain, however, that the fly does not communicate any absolute increase of power to the machine; for if a man, or other animal, is not able to set any mechanical engine in motion without a fly, he will not be able to do it, though a fly be applied, nor will he be able to keep it in motion, though set a-going with a fly, by means of a greater power.

On the Application of Men and Horses, as moving powers in Machinery, &c.—A horse draws with the greatest advantage, when the line of draught is not level with his breast, but inclines upwards, making a small angle with the horizontal plane.

A horse drawing a weight over a single pulley, can draw 200 lbs. for eight hours a day, and walking at the rate of $2\frac{1}{2}$ miles in an hour, which is about $3\frac{1}{2}$ feet in a second; and if the same horse be made to draw 240 lbs. he can work but six hours a day, and cannot go quite so fast. To this may be referred the working of horses in all sorts of mills and water-works, where we ought to know as near as we can, how much we make every horse draw, that we may judge of what the effect will be, when proper allowance shall have been made for all the frictions and hindrances, before we cause any machine to be erected.

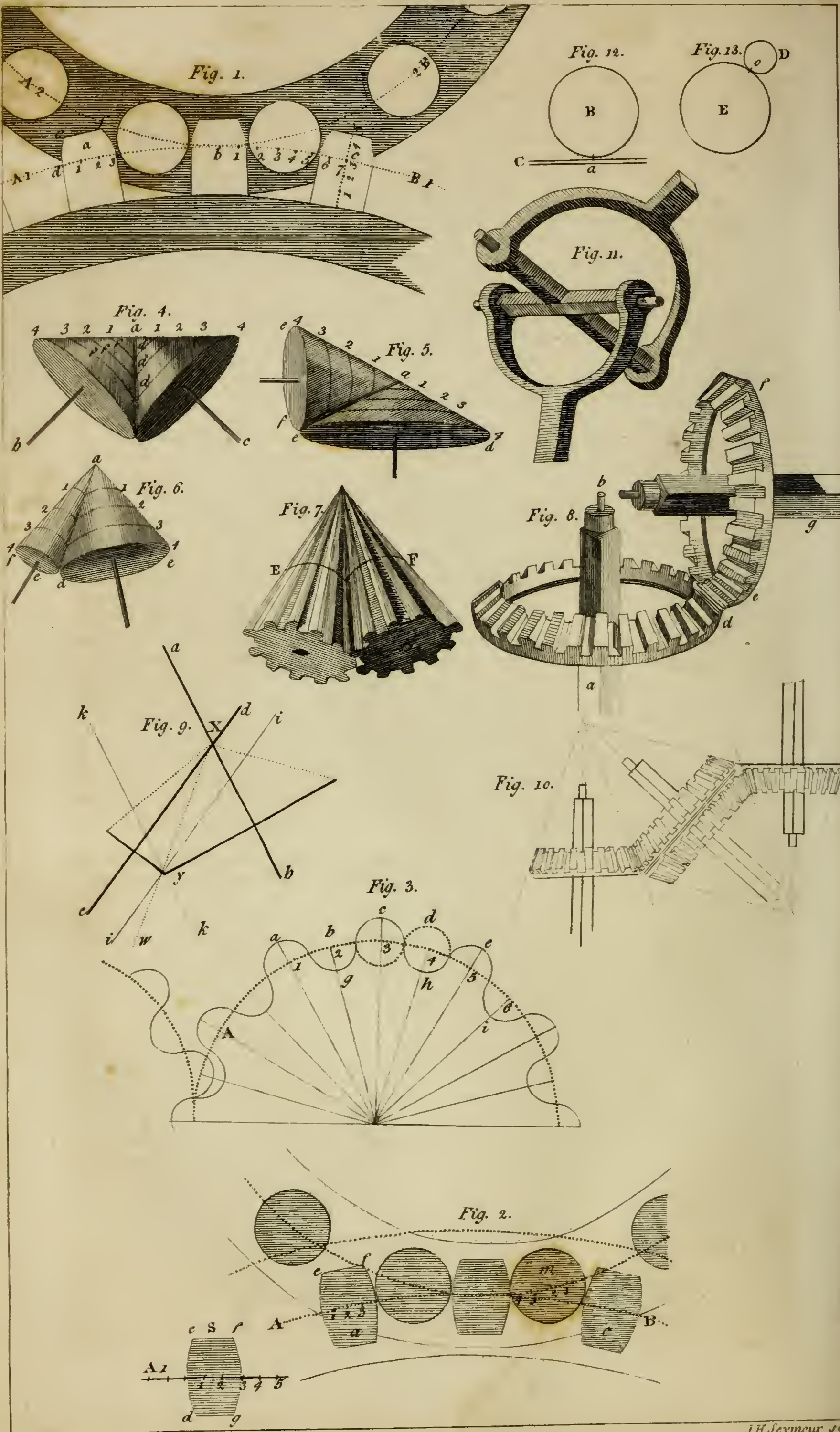
When a horse draws in a mill, or gin of any kind, great care should be taken that the horse-walk, or circle in which he moves, be large enough in diameter, otherwise the horse cannot exert all his strength; for, in a small circle, the tangent (in which the horse draws) deviates more from the circle in which the horse is obliged to go, than in a larger circle. The horse-walk should not be less than 40 feet in diameter, when there is room for it. In a walk of 19 feet diameter, it has been calculated that a horse loses two-fifths of his strength.

The worst way of applying the force of a horse, is to make him carry or draw up hill; for, if the hill be steep, three men will do more than a horse; each man loaded with 100 lb. will move up faster than a horse that is loaded with 300 lb. This is owing to the position of the parts of a man's body, which are better adapted for climbing than those of a horse.

As a horse, from the structure of his body, can exert most strength in drawing almost horizontally in a straight line, a man exerts the least strength that way; as for example, if a man weighing 140 lb. walking by a river or canal side, draws along a boat, or barge, by means of a rope coming over his shoulders, or otherwise fastened to his body, he cannot draw above 27 lb. or about $\frac{1}{27}$ of what a horse can draw in that case. Five men are about equal in strength to one horse, and can with the same ease push round the horizontal beam in a 40 foot walk; but three of the same men will push round a beam in a 19 foot walk, which a horse (otherwise equal to five men) can but draw round.

A man turning an horizontal windlass by a handle, or winch, should not have above 30 lbs. weight acting against him, if he is to work ten hours a day, and raise the weight at the rate of three feet and a half in a second. This supposes, however, that the semi-diameter of the windlass is equal to the distance from the centre to the elbow of the handle; for if there be a mechanical advantage, as there usually is, by having the diameter of the axle, on which the rope winds, four or five times less than the diameter of the circle described by the hand, then may the weight (taking in also the resistance, on account of the friction and stiffness of the rope) be four or five times greater than 30 lb.; that is, so much as it rises slower than the hand moves.

In this operation, the effect of a man's



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force varies in every part of the circle described by the handle. The greatest force is, when a man pulls the handle upwards from about the height of his knees; and the least force when (the handle being at top) he thrusts from him horizontally; then again the effect becomes greater, as a man lays on his weight to push down the handle; but that action cannot be so great as when he pulls up, because he lays on no more than the whole weight of his body; whereas, in pulling, he can exert his whole strength. Lastly, he has but small force to pull the handle towards him horizontally, when at its lowest.

Let us suppose a man of moderate strength to weigh 140 lb. he may in the four principal parts of pushing and pulling, in the whole circumference of motion, exert the following forces, viz. in the strongest point, a force equal to 160 lb.; in the weakest, a force equal to 27 lb.; in the next strong point, 130 lb.; and in the last, or second weak point, 30 lb. Let us add all these forces together, which will make 347; which divide by 4, and we shall have 84¾lb. for the weight that a man might lift by a winch, if he could exert his whole force continually, without stopping to take breath; but as that cannot be, the weight must return, and overpower at the first weak point, especially when the handle moves slowly, as it must, if a man would exert his whole strength all round. Besides, for raising such a weight, we must suppose the man acting always along the tangent of the circle of motion, which does not happen in the operation. Then there must be a sufficient velocity given that the force applied at the strong points may not be spent before the hand comes to the weak ones, so that it is difficult for a man to continue that irregular motion; and therefore, when there are no other advantages, the resistance ought to be but 30 lb. If a fly be added to the windlass when the motion is pretty quick, as about four or five feet in a second, a man may for a little while act with a force of 80 lb. and work a whole day with a resistance of 40 lb.

If two men work at the end of a roller, or windlass, as in drawing up coals or ore from a wine, or water from a well, they may more easily draw up 70 lb. (still supposing the weight and power to have equal velocities) that one man can 30 lb. provided the elbow of one of the handles be at right angles to the other; for then one man will act at the strongest point, when the other acts at the weakest point of the revolution; by which means the two men will mutually and successively help one another, which cannot give the advantage above-mentioned, though there is some little force gained even in that position, because one man pulling while the other thrusts, works at the strongest of the two weak points, whilst the other works at the weakest, and so helps him a little.

When a man carries a burden upon his back, he exerts a great force very effectually, many muscles being at once employed in that operation; the muscles of his neck, back, and loins, keep his body and head in the proper position to sustain the weight; those of his shoulders and arms help to keep it in its place; and the muscles of his legs and thighs raise the weight of all the body and burden as the man walks along. In this way of working, three men do much more than a horse, and two often do as much, as may be observed in the daily labour of the London porters. A porter will carry 200 lb. and walk at the rate of three miles an hour; a coal-heaver will carry 250 lb. but then he does not go far with his load. Chairmen do not act with the same muscles as porters, but as they have straps brought down from their shoulders to the poles of the chair, the muscles of the loins and back are concerned, and likewise the extensors of the legs and thighs; two of them will walk with 300 lb. (that is, 150 lb. each) at the rate of four miles an hour.

The last and most effectual way of a man's exerting his strength, is in rowing a boat; he there acts with more muscles than in any other operation; and the weight of the body also assists him.

To describe the cycloid and epicycloid: of use in shaping the teeth of wheels, &c.

If a point or pencil *a*, (Plate 6, Fig. 12.) on the circumference of the circle B, proceeds along the plane *a* C, in a right line, and at the same time revolves round its centre, it will describe a cycloid.

And, if the generating circle D, (Fig. 13.) moves along the circumference of another circle E, and at the same time turns round its centre, the point *o* will describe an epicycloid.

To apply the cycloid and epicycloid to the teeth of wheels, pinions, racks, &c. so as to cause them to act with the least possible wear, or loss of power by friction.

Having described the genesis of the cycloid and epicycloid, it becomes necessary to shew the manner of applying them, in practice, to the teeth of wheels, pinions, and racks; and to the cams, or lifting cogs, of forges, mills for bruising ore,

pounding gunpowder, beating flax, hemp, &c. so as to cause them to act, with the least possible loss of power, by friction; and first, of the epicycloid.

Fig. 1. (see Plates VII. Mechanics) represents portions of a wheel and pinion; AB, and CD, are the pitch-lines, or primitive diameters, as they are likewise termed; those parts of the teeth contained between the pitch-lines and the rims of the wheel and pinion, are to be made radii, or shaped to lines drawn from the divisions in the pitch-lines to the centres of the wheel and pinion; the curved parts above the pitch-lines, reaching to the ends of the teeth, must be portions of epicycloids; in order to produce which, let two segments or portions of circles, equal to the radii of the pitch-lines, be drawn upon a smooth oaken or other plank, not less than half an inch in thickness, and let it be sawn or otherwise exactly shaped to those curves; see Figs. 2 and 3; the first of which, being of the same curvature with the pitch-line of the pinion CD, and the second the same sweep as that of the wheel AB, a hole must then be bored obliquely in each, commencing a quarter of an inch from the edge on one side, and terminating in the edge of the opposite side; into each of which holes a nail, &c must be driven until the points project a little below the holes, as at EE; these points must then be filed, so as to leave them exactly in the peripheries of the circles, just long enough to make an impression upon any plane surface placed beneath them, and must be rounded and made conical, so as to trace a smooth even line; then, after having rubbed the sides, or circular edges of the segments, with powdered resin, fix the segment (Fig. 2. fast upon the pitch-line of the pinion; and apply the tracing point in the other segment (Fig. 3.) successively to all the divisions of the teeth in the said pitch-line, and pressing its edge close to the edge of the fixed segment, cause it to roll or revolve about it, without slipping one way or the other, until it shall have described the curves proper for all the teeth of the pinion; then, taking off the small segment from the pinion, fasten the larger one upon the pitch-line of the wheel; and proceed to describe the curves of the teeth of the wheel, with the tracing point in the small segment, exactly in the same manner as those of the pinion.

The teeth in bevel-geer, should also be made partly radii and partly epicycloidal; but to describe the mode of applying that curve to them, would far exceed our limits

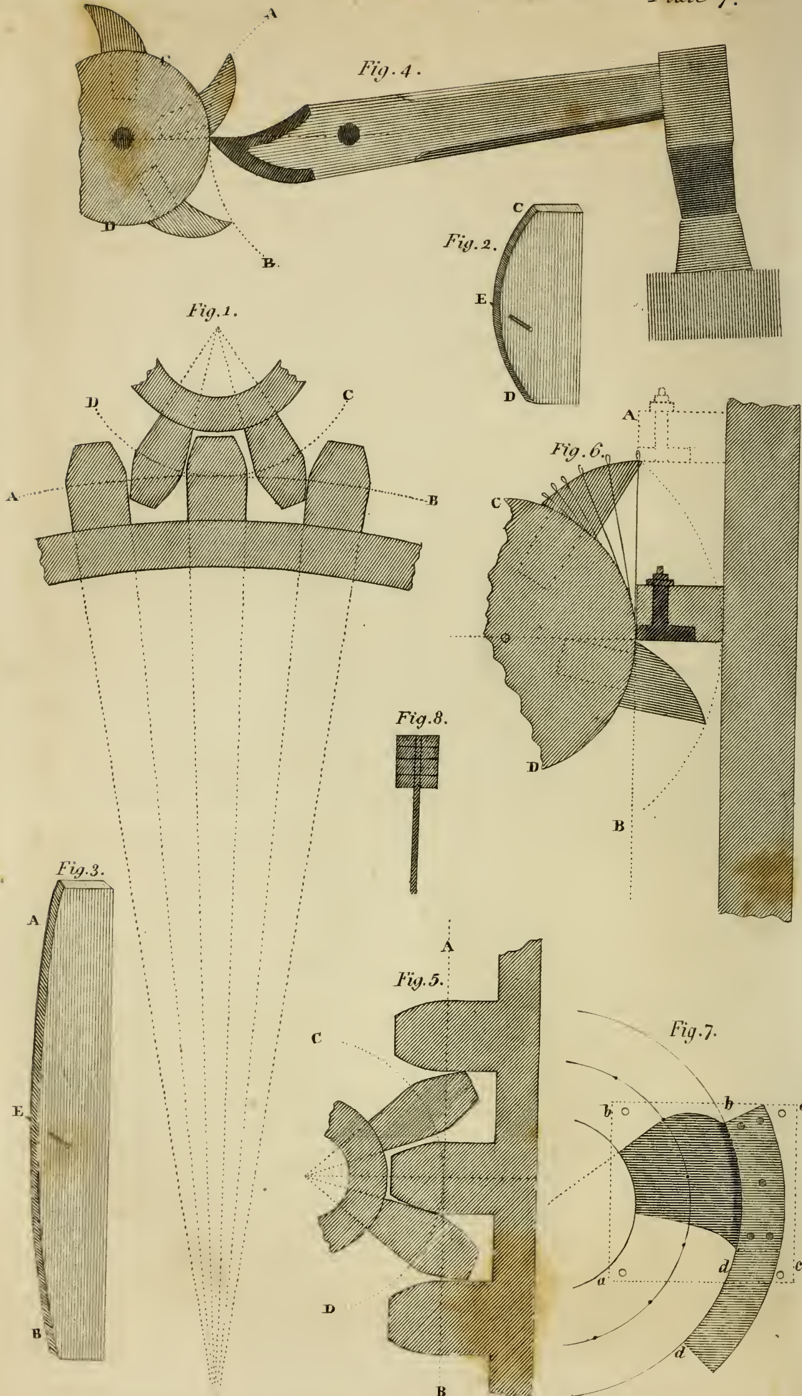
We shall next proceed to explain the method of applying the epicycloid to the lifting cogs or cams, of forge hammers, or other similar purposes, where both the moving bodies describe arcs of circles: in this case, as only one tooth cog, or cam, acts at a time, we need only form two segments of circles: one corresponding with the radius of the mill shaft, or the place where the cog begins to act upon the hammer tail, as CD, (Fig. 4.) and the other equal to the distance from the axis of the hammer to the aforesaid radius, as AB; then fixing the segment CD, in the manner before-mentioned, upon a circle of the same radius, drawn upon any fit plane surface, we must furnish the other segment, AB, with a tracing point, and proceed as before to describe the curves proper for the lifting cogs: that part of the hammer tail, upon which they act, requiring only to be made flat, and placed in a line drawn through both axes.

Fig. 5, represents portions of a rack and pinion: CD, the primitive diameter, or pitch-line of the pinion; and AB, the pitch-line of the rack; the sides of the teeth in the pinion, from the pitch-line to their bottoms, are to be made radii, as in Fig. 1; but the sides of the teeth in the rack, below the pitch-line, must be drawn at right angles to the pitch-line: the curved parts of the teeth in the pinion, and rack likewise are to be made cycloidal, by forming a circular segment corresponding with the radius of the pitch-line of the pinion; and a straight-edge or ruler, both being furnished with tracing-points in their edges; then fixing the circular segment fast upon the pitch-line of the pinion, proceed to describe all the curved parts of its teeth, by placing the tracing-point in the edge of the straight ruler, successively in all the divisions in the pitch-line of the pinion, and rolling it either one way or the other, upon the circular segment, without slipping; then, fixing the straight-edge fast upon the primitive or pitch-line of the rack, take off the circular segment from the pinion, and placing its tracing-point in the divisions made in the pitch-line of the teeth of the rack, roll it upon the straight-edge, either one way or the other, as before directed, until all the curves of the rack teeth are also traced.

Fig. 6. represents portions of a stamper of a mill for bruising ore, pounding gunpowder, beating hemp, &c. and of its shaft with lifting-cogs; AB, is a line corresponding with that part of the arm of the stamper upon which the lifting-cogs first act; CD, is the pitch-line of the axis, or the bottom of the curves of the lifting-cogs: in this case we need not be at the trouble of making segments; but describing a portion of a circle of the radius of the said

Mill Work.

Plate 7.



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pitch-line, upon any plane surface of wood, we drive a number of small nails, or tacks, into the said circular arc, leaving them standing half an inch above the surface of the wood; then fixing a thread to the endmost nail, we make a loop at its other extremity, in which we place a tracing-point, or pencil, E; and keeping the thread stretched tight, cause it to form tangents to the circular arc CD; and thus the tracer will describe a curved line, being a portion of a cycloid, upon the plane surface of wood; which curved line is the proper form for the lifting-cogs of the mill-shaft: the arm of the stamper should be made flat at the part where the lifting-cogs act upon it, and should be placed in a line pointing to the centre of the mill-shaft, at the time the cog first comes into contact with it.

To form a templet, or Pattern Tooth, to facilitate the application of the cycloid and epicycloid, to the teeth of wheels, pinions, &c.

As, however, it would in all cases be tedious, and in some nearly impracticable, to generate these lines and curves upon every tooth in a wheel, pinion, rack, &c. we shall describe an easy mode of forming a templet, or pattern tooth, and the manner of applying it with facility, not only to the large teeth of wheels and pinions in mill-work, but also to the teeth of the smaller wheels, &c. employed in cotton works, clocks, watches, &c.

In order to which, having determined the radii of the pitch-lines, and made segments, corresponding thereto; having likewise determined the height and the depth of the teeth, and divided the pitch-lines into teeth and spaces, as before: then, for wheels and pinions, instead of applying the segments immediately upon the wheels or pinions themselves, we take a plate of brass or other proper metal, *a, a*, (Fig. 7.); and fasten it (by means of pins, driven through holes, made in its corners) upon any plane surface of wood; we then describe upon it, by means of compasses or beam compasses, the lines corresponding with the primitive diameter or pitch-line, and tops and bottoms of the teeth in the wheel or pinion: and fixing the correspondent segment, fast upon its pitch-line, with the point fixed in the other segment, describe that portion of the epicycloid which reaches from the pitch-line to the tops of the teeth; then, after having taken off the fixed segment, draw a radius line from the commencement of the curve in the pitch-line, to the bottoms of the teeth; and taking the metal plate off from the plane surface, accurately file or shape one edge of it from *b* to *b*, to those lines so drawn, and likewise shape its upper and lower edges to the circular arcs described upon it; the extra portion from *c*, to *c*, may likewise be removed; then, taking a piece of wood (or in case of small works, metal) of a proper thickness and breadth, and long enough to extend over at least two of the teeth, describe upon it a circular arc, *d, d*, exactly equal in radius to the tops of the teeth, and then slitting one end of it from *b* to *d*, fix into that slit, the metal plate, before described by that part of it, which extends above the line *b, d*; observing that it be so placed in the slit, as exactly to correspond with its situation when generated; that is to say, that the radius line of the templet, may point exactly to the centre of the circular arc *d, d*, of the piece of wood thus slit; and the similar arc *b, d*, of the templet, be in contact with that arc; it must then be fastened in that position, by drilling holes through both pieces, and rivetting them together, so as to leave a projecting shoulder on each side of the templet, as shewn by Fig. 8

Mr. Oliver Evans, of Philadelphia, has devoted much time and made great improvements in mill machinery, and other branches of mechanics. A tract of which he is the author, entitled, *The young mill-wright's and miller's guide*, is divided into the following five parts:

1. Mechanics and Hydraulics, shewing errors in the old, and establishing a new system of theories of water mills, by which the power of mill-seats, and the effects they will produce may be ascertained by calculation.

2. Rules for applying the theories to practice, tables for proportioning mills to the power and fall of the water, and rules for finding pitch circles, with tables from 6 to 136 cogs.

3. Directions for constructing and using all the author's patent improvements in mills.

4. The art of manufacturing meal and flour in all its parts, as practised by the most skilful millers in America.

5. The Practical Mill wright; containing instructions for building mills, with tables of their proportions suitable for all falls from three to thirty-six feet; with an Appendix, containing rules for discovering how improvements made may be exemplified in improving the art of cleaning grain, hulling rice, warming rooms, and venting smoke by chimneys, &c.

The following specification of sundry improvements in mill machinery, we have been favoured with by Mr. Evans, the patentee.

"My first principle is to elevate the

meal as fast as it is ground in small separate parcels, in continued succession and rotation, to fall on the cooling floor, to spread, stir, turn and expose it to the action of the air, as much as possible, and to keep it in constant and continual motion, from the time it is ground until it be bolted: this I do to give the air full action, to extract the superfluous moisture from the meal, while the heat generated by the friction of grinding will repel and throw it off, and the more effectually dry and cool the meal fit for bolting in the course of the operation, and save time and expence to the miller. Also to avoid all danger from fermentation by its laying warm in large quantities as is usual; and to prevent insects from depositing their eggs which may breed the worms often found in good flour. And further to complete this principle so as to dry the meal more effectually, and to cause the flour to keep sweet a longer space of time, I mean to increase the heat of the meal as it falls ground from the mill-stones by application of heated air, that is to say, to kiln-dry the meal as it is ground, instead of kiln-drying the grain as usual. The flour will be fairer and better than if made from kiln-dried grain, the skin of which is made so brittle that it pulverizes and mixes with the flour. This principle I apply by various machines which I have invented, constructed and adapted to the purposes hereafter specified, numbered 1, 2, 3, 4, 5.

My second principle is to apply the power that moves the mill or other principal machine to work my machinery, and by them to perform various operations which have always heretofore been performed by manual force, and thus greatly to lessen the expence and labour of attending mills and other works.

The application of those principles including that of kiln-drying the meal during the process of the manufacture or otherwise, to the improvement of the process of manufacturing flour, and for other purposes, is what I claim as my invention and improvement in the art, as not having been known or used before my discovery: knowing well that the principles once applied by one set of machinery, to produce the desired effect, others may be contrived and variously constructed and adapted to produce like effects in the application of the principles, but perhaps none to produce the desired effect more completely than those which I have invented and adapted to the purposes, and which are hereinafter specified.

No. 1. *The Elevator.*—Its use is to elevate any grain, granulated or pulverized substances. Its use in the manufacture of flour or meal is to elevate the meal from the millstones in small separate parcels, and to let it fall through the air on the cooling floor, as fast as it is ground. It consists of an endless strap, rope or chain, with a number of small buckets attached thereto, set to revolve round two pulleys, one at the lowest, and the other at the highest point between which the substance is to be raised. These buckets fill as they turn under the lower, and empty themselves as they turn over the upper pulley. The whole is inclosed by cases of boards to prevent waste.

No. 2. *The Conveyer.*—Its use is to convey any grain, granulated or pulverized substances in a horizontal, ascending or descending direction. Its use in the process of the art of manufacturing flour, is to convey the meal from the millstones, as it is ground, to the elevator to be raised and to keep the meal in constant motion, exposing it to the action of the air, also in some cases to convey the meal from the elevator to the bolting hopper, and to cool and dry it fit for bolting, instead of the hopper boy, No. 3; also to mix the flour after it is bolted; also to convey the grain from one machine to another, and in this operation to rub the impurities off the grain. It consists of an endless screw, set to revolve in a tube or section of a tube, receiving the substance to be moved, at one end, and delivering it at the other end; but, for the purpose of conveying flour or meal, I construct it as follows: Instead of making it a continued spiral, which forms the endless screw, I set small boards called flights, at an angle crossing the spiral line; these flights operate like so many ploughs following each other, moving the meal from one end of the tube to the other with a continued motion, turning and exposing it to the action of the air to be cooled and dried. Sometimes I set some of the flights to move broadside foremost to lift the meal from one side to fall on the other to expose it to the air more effectually.

No. 3. *The Hopper Boy.*—Its use is to spread any grain, granulated or pulverized substances, over a floor or even surface, to stir it and expose it to the air to dry and cool it, when necessary; and at the same time to gather it from the circumference of the circle it describes, to, or near the centre, or to spread it from the centre to the circumference, and leave it in the place where we wish it to be delivered, when sufficiently operated on. Its use in the process of manufacturing flour is to spread the meal as fast as it falls from the elevator over the cooling floor,

on the area of a circle of from eight to sixteen feet more or less in diameter, according to the work of the mill, to stir and turn it continually, and to expose it to the action of the air to be dried and cooled, and to gather it into the bolting hoppers, and to attend the same regularly. It consists of an upright shaft made round at the lower end, about two-thirds of its length, and set to revolve on a pivot in the centre of the cooling floor; through this shaft, say five feet from the floor, is put a piece called the leader, and the lower end of the shaft passes very loosely through a round hole in the centre of another piece called the arms, say from eight to sixteen feet in length, this last piece revolving horizontally, describes the circle of the cooling floor, and is led round by a cord, the two ends of which are attached to the two ends of the arms, and passing through a hole at each end of the leader, so that the cord will reeve to pull each end of the arms equally The weight of the arms is nearly balanced by a weight hung to a cord, which is attached to the arms, and passes over a pulley near to the upper end of the upright shaft, to cause the arms to play lightly, pressing with only part of their weight on the meal that may be under it. The foremost edges of the arms are sloped upwards, to cause them to rise over and keep on the surface of the meal as the quantity increases: and if it be used separately and unconnected with the elevator, the meal may be thrown with shovels within its reach, while in motion, and it will spread it level, and rise over it, until the heap be four feet high or more, which it will gather into the hoppers, always taking from the surface, after turning it to the air a great number of times. The underside of these arms are set with little inclining boards called flights, about four inches apart next the centre, and gradu ally closing to about two inches next the extremities, the flights of the one arm to track between those of the other, they operate like ploughs, and at every revolution of the machine, they give the meal two turns towards the centre of the circle, near to which are generally the bolting hoppers. At each extremity of the arms there is a little board attached to the hindmost edge of the arm to move side foremost; these are called sweepers, their use is to receive the meal as it falls from the elevator, and trail it round the circle described by the arms, that the flights may gather it towards the centre from every part of the circle; without these, this machine would not spread the meal over the whole area of the circle described by the arms. Other sweepers are attached to that part of the arms which pass over the bolting hoppers to sweep the meal into them.

But if the bolting hoppers be near a wall and not in the centre of the cooling floor, then in this case the extremity of the arms are made to pass over them, and the meal from the elevator let fall near the centre of the machine, and the flights are reversed to turn the meal from the centre towards the circumference, and the sweepers will sweep it into the hoppers. Thus this machine receives the meal as it falls from the elevator on the cooling floor, spreads it over the floor, turns it twice over at every revolution, stirs and keeps it in continual motion, and gathers it at the same operation into the bolting hoppers, and attends them regularly. If the bolting reels are stopped, this machine spreads the meal and rises over it, receiving under it from one, two to three hundred bushels of meal, until the bolts are set in motion again, when it gathers the meal into the hoppers, and as the heap diminishes, it follows it down until all is bolted I claim as my invention, the peculiar properties or principles which this machine possesses, viz. the spreading, turning and gathering the meal at one operation, and the rising and lowering of of its arms by its motion to accommodate itself to any quantity of meal it has to operate on.

No. 4. *The Drill.*—Its use is to move any grain, granulated or pulverized substance from one place to another: it consists, like the elevator, of an endless strap, rope or chain, &c. with little rakes instead of buckets (the whole cased with boards to prevent waste) revolving round two pulleys or rollers. Its use in the process of the manufacture of flour is to draw or rake the grain or meal from one part of the mill to another. It receives it at one pulley, and delivers it at the other, in a horizontal, ascending or descending direction, and in some cases may be more conveniently applied for that purpose than the conveyer. I claim the exclusive right to the principles and to all the machines above specified, and for all the uses and purposes specified, as not having been heretofore known or used before I discovered them. They may all be united and combined in one flour mill to produce my improvement on the art of manufacturing flour complete, or they may each be used separately for any of the purposes specified and allotted to them or to produce my improvement in part, according to the circumstances of the case.

No. 5. *The Kiln-Drier*—To kiln-dry the

meal after it is ground, and during the operation of the process of manufacturing flour, I take a close stove of any common form, and inclose it with a wall made of the best non-conductor of heat, leaving a small space between the stove and the wall, to admit air to be heated in its passage through this space. I set this stove below the conveyor, that conveys the meal from the mill-stones, as ground into the elevator, and I connect the space between the stove and the wall, to the conveyor tube, by a pipe entering near the elevator, and I cover the conveyor close, and set a tube to rise from the end of the conveyor tube, near the mill-stones, for the heated air to ascend and escape as up a chimney. I make fire in the stove and admit air at the bottom of the space between it and the wall round it, to be heated and pass along the conveyor tube, meeting the meal which will he heated by the hot air, and the superfluous moisture will be more powerfully repelled and thrown off and the meal will be dried and cooled as it passes through the operation of the elevator and hopperboy. The flour will be fairer than if the grain had been kiln-dried, and it will keep longer sweet than flour not kiln-dried I set all my machines in motion by the common means of cog and round tooth and pinion straps, ropes, or chains, well known to every millwright.

Arrangement and connexion of the several machines, so as to apply my principles to produce my improvements complete.

I fix a spout through the wall of the mill for the grain to be emptied into from the waggoner's bag, to run into a box hung at the end of a scale beam, to weigh a waggon load at a draught. From this box it descends into the grain elevator, which raises it to a granary over the cleaning machines, and as it passes through them, it may be directed into the same elevator to ascend, to be cleaned a second time, and then descends into a granary, over the hopper of the millstones to supply them regularly, and as ground it falls from the several pair of millstones into the conveyers, where it is dried by the heated air of the kiln-drier, and is conveyed into the meal elevator, to be raised and dropped on the cooling floor within reach of the hopper-boy, which receives and spreads it over the whole area of the circle which it describes, stirring and turning it continually, and gathering it into the bolting hoppers which it attends regularly. That part of the flour which is not sufficiently bolted by the first operation, is conveyed by a conveyer or drill into the elevator, to ascend with the meal to be bolted over again, and that part of the meal which has not been sufficiently ground at the first operation is conveyed by a conveyer or drill, and let run into the eye of the millstone to be ground over.

Thus the whole of the operations which used to be performed by manual labour is, from the time the wheat is emptied from the waggoner's bag, or from the ship's measure, until it enters the bolts and the manufacture be completed in the most perfect manner, performed by the machinery moved by the power which moves the mill, and this machinery keeps the meal in constant motion during the whole process, drying and cooling it more completely, avoiding all danger from fermentation, and preventing insects from depositing their eggs, and performing all the operations of grinding and bolting, to much greater perfection, making the greatest possible quantity of the best quality of flour out of the grain, saving much time and labour and expence to the miller, and preventing much from being wasted by the motion of the machines being so slow as to cause none of the flour to rise in form of dust and be carried away by the air, and the cases of the machines being made close prevents any from being lost."

The following letter may also be noticed:—

The principles of these improvements consist,

1. In the subdivision of the grain, or any granulated or pulverized substance; in elevating and conveying them from place to place in small separate parcels; in spreading, stirring, turning and gathering them by regular and constant motion, so as to subject them to artificial heat, the full action of the air to cool and dry the same when necessary, to avoid danger from fermentation, and to prevent insects from depositing their eggs during the operation of the manufacture.

2. In the application of the power which moves the mill or other principal machine, to work any machinery which may be used to apply the said principles, or to perform the said operations by constant motion and continued rotation, to save expence and labour.

The machinery by him already invented and used for applying the above principles, consists of an improved elevator, an improved conveyor, an improved hopper-boy, an improved drill, and an improved kiln-drier.

The method for setting out a spur-wheel and wallower.—Draw the pitch lines A1, B1, A2, 2B; (Plate V. Fig. 1.) then divide them into the number of teeth or cogs required, as *a b c*.

Divide one of these distances, as *b c*,

into seven equal parts, as 1, 2, 3, 4, 5, 6, 7; three parts allow for the thickness of the cogs, as 1, 2, 3, in the cog *a*, and four for the thickness of the stave of the wallower. One reason for allowing three parts for the cog, and four for the stave is, the wallower is in general of less diameter than the wheel, therefore subject to more wear, in proportion of the number of cogs to the number of staves; but if there is the same number of staves as of cogs, they may be of equal thickness, as 1, 2, 3, 4, in the stave *m*, (Fig. 2;) the height of the cog is equal to four parts; then divide its height into five equal parts, as 1, 2, 3, 4, 5, in the cog C; allow three for the bottom to the pinch-line of the cog; the other two parts for epicycloid, so as to fit and bear on the stave equally. The millwrights in general, put the point of a pair of compasses in the dot 3 of the cog *a*, and strike the line *d*, *e*; then remove the point of the compasses to the point *d*, and strike the curve line 3 *f*, which they account near enough the figure of the epicycloid.

The method for a face-wheel is thus: divide the pitch-line AB (Fig. 2.) into the number of cogs intended, as *a b c*; divide the distance *b c*, into seven equal parts; three of those parts allow for the thickness of the cogs, as 1, 2, 3, in the cog *a*, four for the height, and four for the width, as *d*, *e*, and four for the thickness of the stave *m*; draw a line through the centre of the cog, as the line AI, at S; and on the point 5, describe the line *d e*; remove the compasses to the point A, and draw the line *f g*, which forms the shape of the cog; then shape the cog on the sides to a cycloid, as *d e f g* (Eig. 1.) But this method of setting out the shape of a cog is variable, according to the cycloid in different diameters of wheels.

In common spur-nuts, divide the pitch-line A, into twice as many equal parts as you intend teeth, as *a b c d e*, (Fig. 3.) with a pair of compasses opened to half the distance of any of those divisions, from the points *a* 1, *c* 3, *e* 5, draw the semicircles *a*, *c*, and *e*, which will form the ends of the teeth. From the points 2, 4, and 6, draw the semicircles *g h i*, which will form the hollow curves for the spaces; but if the ends of the teeth were epicycloids instead of semicircles, they would act much better.

Bevel-geer.—Instead of spur-wheels and truddles, bevelled-wheels, commonly called bevel-geer, are now generally used.—Their principle consists in two cones rolling on the surface of each other, as the cone A and B revolving on their centres *a b*, *a c*; (Fig. 4.) if their bases are equal, they will perform their revolutions in one and the same time, or any other two points, equally distant from the centre *a*, as *d* 1, *d* 2, *d* 3, &c. will revolve in the same time as *f* 1, *f* 2, *f* 3, &c. In the like manner, if the cones *a d e*, be twice the diameters at the base *d e*, as the cones *a f e* are, then if they turn about their centres when the cone *a f e* (Fig. 5 and 6) has made one revolution, the cone *a d e* will have made but half a revolution; or when *a f e*, has made two revolutions, *a d e* will have made but one, and every part equally distant from the centre *a*, as *f* 1, *f* 2, *f* 3, &c. will have made two revolutions to *e* 1, *e* 2, *e* 3, &c. and if the cones were fluted, or had teeth cut in them, diverging from the centre *a* to the base *d c*, *e f*, (Fig. 7.) they would then become bevel-geer. The teeth at the point of the cone being small, and of little use, may be cut off at E and F, (Fig. 7 and 8.) where the upright shaft *a b*, with the bevel-wheel, *c d*, turns the bevel-wheel *e f* with its shaft *b g*, and the teeth work freely into each other. The teeth may be made of any dimension, according to the strength required; and this method will enable them to overcome a much greater resistance, and work smoother than a face-wheel and wallower of the common form can possibly do; besides, it is of great use to convey a motion in any direction, or to any part of a building, with the least trouble and friction.

The method of conveying a motion in any direction, and proportioning or sharpening the wheels thereto, is as follows: let the line *a b* represent a shaft coming from a wheel; draw the line *c d* to intersect the line *a b*, (Fig. 9.) in the direction that the motion to be conveyed is intended, which will now represent a shaft to the intended motion.

Again, suppose the shaft *c d* is to revolve three times, whilst the shaft *a b* revolves once; draw the parallel line *i i* at any distance not too great (suppose one foot by a scale,) then draw the parallel line *k k* at three feet distance, after which, draw the dotted line *w x*, through the intersection of the shafts *a b* and *c d*, and likewise through the intersection of the parallel lines *i i* and *k k*, in the point *x* and *y*, which will be the pitch-line of the two bevel-wheels, or the line where the teeth of the two wheels act on each other, as may be seen Fig. 10, where the motion may be conveyed in any direction.

The universal joint, as represented Fig. 11, may be applied to communicate motion instead of bevel-geer, where the speed is to be continued the same, and where

the angle does not exceed 30 or 40 degrees, and the equality of motion is not regarded; for as it recedes from a right line, its motion becomes more irregular. This joint may be constructed by a cross, as represented in the figure; or with four pins fastened at right-angles upon the circumference of a hoop, or solid ball. It is of great use in cotton mills, where the tumbling shafts are continued to a great distance from the moving power. But by applying this joint, the shafts may be cut into convenient lengths, by which it will be enabled to overcome greater resistance.

Further Observations on Sundry Parts of Machinery.

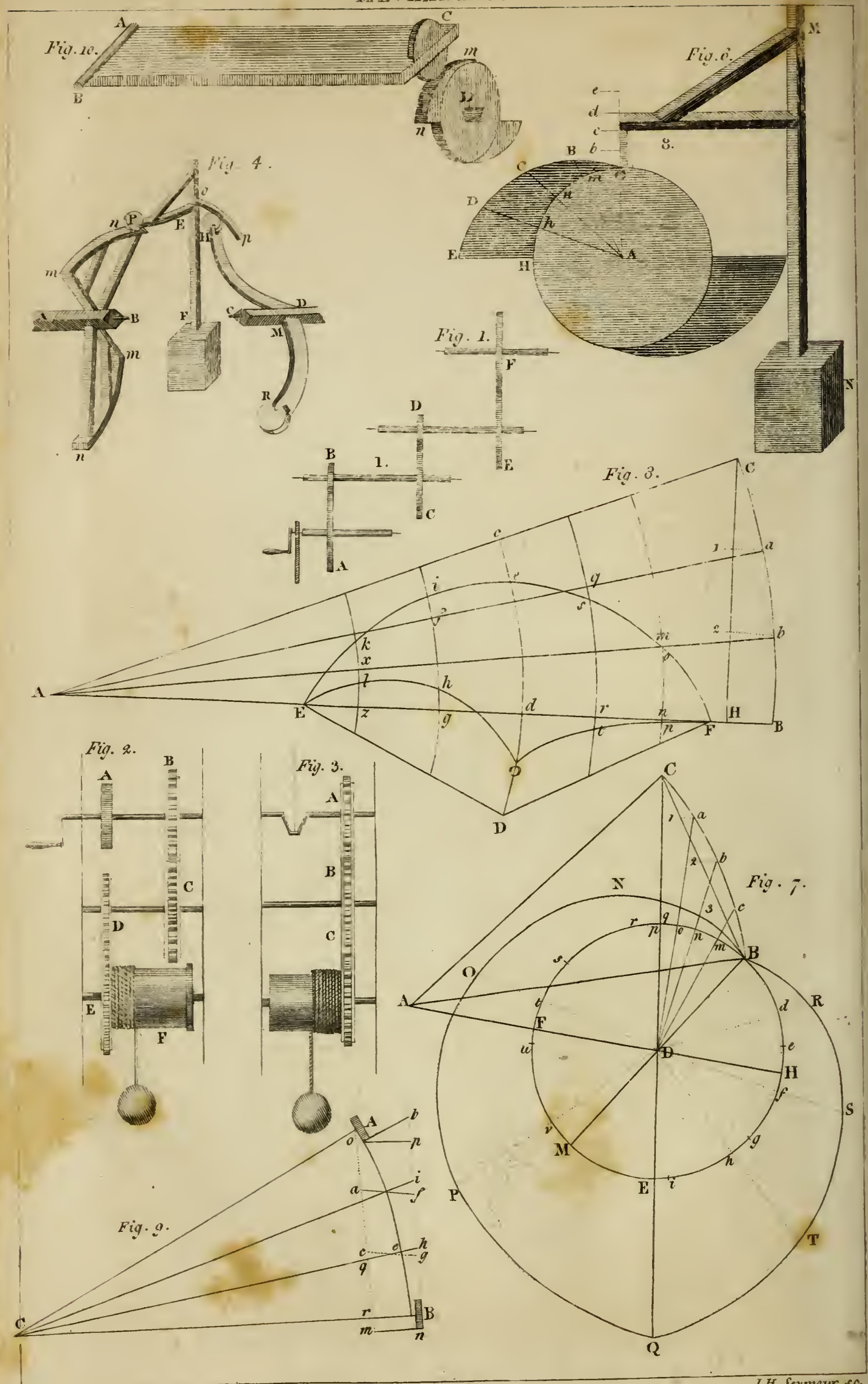
In machinery, where large weights are to be raised, such as fulling-mills, mills for pounding, &c. or where large pistons are to be elevated by the arms of levers, it is of the greatest consequence that the power should raise the weight with a uniform force and velocity; and this can be effected only by giving a proper form to the wipers or communicating parts. A certain class of mechanics generally excuse themselves for not attending to the proper form of the teeth of wheels, by alleging that the scientific form differs but little from theirs, and that teeth, however badly formed, will in the course of time, work into their proper shape. This excuse, however, will not apologize for their negligence in the present case. The scientific form of the wipers or stampers, and the arms of levers are so widely different from the form which is generally assigned them, as to increase very much the performance of the machine, and preserve its parts from the injury which is always occasioned by the want of a uniform motion.

Now there are two cases in which this uniformity of motion may be required, and each of these demands a different form for the communicating parts. 1. When the weight is to be raised perpendicularly, as the piston of a pump, &c. 2. When the weight to be raised or depressed moves upon a centre, and rises or falls in the arch of a circle, such as the sledge-hammer in a forge, the stampers in a fulling-mill, &c.

1. In Fig. 4, of Plate VIII. let AB be an axis driven by a water-wheel or any other power, at right angles to which is fixed the bar *mm*, on whose extremities the wipers *mn mn* are fastened. The wiper *mn* acting upon the arm PE, raises the piston or weight EF to the required height. The piston then falls, and is again raised by the lower wiper. It often happens that two or three pistons are to be employed, and in this case the axis AB must carry four or six wipers, which should be so distributed upon its circumference that when one piston is about to fall, the other may begin to rise. Now, in order that these pistons may be raised with a uniform motion, the form of the wiper *mn* must be the evolute of a circle whose diameter is *mm*; or, in other words, it must be an epicycloid, formed by a generating circle, whose centre is infinitely distant, rolling upon the convex circumference of another circle whose diameter is *mm*. But as a small roller P, is frequently fixed to the extremity of the arm E, to diminish the friction of the working parts, we must draw a curve within the above-mentioned involute, and parallel to it, the distance between them being equal to the radius of the roller; and this new curve will be the proper form for the wiper *mn* when a roller is employed.

The piston may also be raised or depressed uniformly, by giving a proper curvature to the arm PE, and fixing the roller upon the extremities of the bar *mm*. Thus in Fig. 4, let CD be an axis, moved by any power, in which are fixed the arms DH, MR, having rollers HR at their extremities, which act upon the curved arm *op*. When the piston EF is raised to the proper height by the action of the roller H upon *op*, it then falls, and is again elevated by the arm M. In order that its motion may be uniform, the arm *op* must be part of a cycloid, the radius of whose generating circle is equal to the length of the arm DH, reckoning from its extremity H, or the centre of the roller, to the centre of the axle DC. But when a roller is fixed upon the extremity H, we must draw a curve parallel to the cycloid, and without it, at the distance of the roller's semidiameter; and this curve will be the proper form for the arm *op* It is evident that when this mode of raising the piston is adopted, the arm DH must be bent as in the figure, otherwise the extremity *p* would prevent the roller H, from acting upon the arm *op*.

In Fig. 6. we have another method of raising a weight perpendicularly with a uniform motion. Let AH be a wheel moved by any power which is sufficient to raise the weight MN by its extremity O, from O to *e*, in the same time that the wheel moves round one-fourth of its circumference, it is required to fix upon its rim a wing OBCDEH which shall produce this effect with a uniform effort. Divide



J.H. Seymour sc.

the quadrant OH into any number of equal parts Om mn, &c. the more the better, and oe into the same number ob, bc, cd, &c. and through the points m, n, p, H, draw the indefinite lines AB, AC, AD, AE, and make AB equal to Ab, AC to Ac, AD to Ad, and AE to Ae; then through the points O,B,C,D,E, draw the curve OBCDE which is a portion of the spiral of Archimedes, and will be the proper form for the wiper or wing OHE. It is evident that when the point m has arrived at O, the extremity of the weight will have arrived at b; because AB is equal to Ab, and for the same reason when the points n, p, H have successively arrived at O, the extremity of the weight will have arrived at the corresponding points c, d, e. The motion therefore will be uniform, because the space described by the weight is proportional to the space described by the moving power, Ob being to Oc as Om to On. If it be required to raise the weight MN with an accelerated or retarded motion, we have only to divide the line Oe, according to the law of acceleration or retardation, and divide the curve O B C D E as before.

2. When the lever moves upon a centre, the weight will rise in the arch of a circle, and consequently a new form must be given to the wipers or wings. The celebrated Deparcieux, of the Academy of Sciences of Paris, has given an ingenious and simple method of tracing mechanically the curves which are necessary for this purpose. Though this method was published about fifty years ago in the Memoirs of the Academy, it does not seem to be at all known to the mechanics of this country. We shall therefore lay it before the reader in as abridged and simplified a form as the nature of the subject will permit Let AB, Fig. 7, be a lever lying horizontally, which it is required to raise uniformly through the arch BC into the position AC, by means of the wheel BFH furnished with the wing BNOP, which acts upon the extremity C of the lever; and let it be required to raise it through BC in the same time that the wheel BFH moves through one half of its circumference; that is, while the point M moves to B in the direction MFB. Divide the chord CB into any number of equal parts, the more the better, in the points 1, 2, 3, and draw the lines 1a, 2b, 3c, parallel to AB, or a horizontal line passing through the point B, and meeting the arch CB in the points a, b, c. Draw the lines CD, aD, bD, cD, and BD, cutting the circle BFH in the points m, n, o, p.

Having drawn the diameter BM, divide the semicircle BFM into as many equal parts as the chord CB, in the points q, s, u. Take Bm and set it from q to r: Take Bn and set it from s to t: Take Bo and set it from u to v: and lastly, set Bp from M to E. Through the points r, t, v, E, draw the indefinite lines DN, DO, DP, DQ, and make DN equal to Dc; DO equal to Db; DP equal to Da; and DQ equal to DC. Then through the points Q, P, O, N, B, draw the spiral B, N, O, P, Q, which will be the proper form for the wing of the wheel when it moves in the direction EMB.

That the spiral BNO, will raise the lever AC, with a uniform motion by acting upon its extremity c, will appear from the slightest attention to the construction of the figure. It is evident, that when the point q arrives at B, the point r will be in m, because Bm is equal to qr, and the point N will be at c, because DN is equal to Dc; the extremity of the lever, therefore, will be found in the point c, having moved through Bc. In like manner, when the point s has arrived at B, the point t will be at n, and the point O in b, where the extremity of the lever will now be found; and so on with the rest, till the point M has arrived at B. The point E will then be in p, and the point Q in C; so that the lever will now have the position AC, having moved through the equal heights B c, c b, b a, a c, in the same time that the power has moved through the equal spaces q B, s q, u s, M u. The lever, therefore, has been raised uniformly, the ratio between the velocity of the power, and that of the weight, remaining always the same.

If the wheel D turns in a contrary direction, according to the letters MHB, we must divide the semicircle BH EM, into as many equal parts as the chord c B, viz. in the points e, g, h. Then, having set the arch B m, from e to d, the arch B n from g to f, and the rest in a similar manner, draw through the points d, f, h, E, the indefinite lines DR, DS, DT, DQ, make DR equal to Dc; DS equal to Db; DT equal to Da, and DQ equal to DC; and through the points B, R, S, T, Q, describe the spiral BRSTQ, which will be the proper form for the wings, when the wheel turns in the direction MEB. For, when the point e arrives at B, the point d will be in m, and R in c, where the extremity of the lever will now be found, having moved through B c in th same time that the power, or wheel, has moved through the division e B. In the same manner it may be shown, that the lever will rise through the equal heights c b, b a, a C, in the same time that the power moves through the corresponding spaces

e, g, g, i, i M. The motion of the lever, therefore, and also that of the power, are always uniform. Of all the positions that can be given to the point B, the most disadvantageous are those which are nearest the points F, H; and the most advantageous position is when the chord B c is vertical, and passes, when prolonged, through D, the centre of the circle. In this particular case, the two curves have equal bases, though they differ a little in point of curvature. The farther that the centre A is distant, the nearer do these curves resemble each other; and if it were infinitely distant, they would be exactly similar, and would be the spirals of Archimedes, as the extremity c would in this case rise perpendicularly.

The intelligent reader will easily perceive, that 4, 6, or 8 wings may be placed upon the circumference of the circle, and may be formed by dividing into the same number of equal parts as the chord B C, $\frac{1}{4}$, $\frac{1}{6}$ or $\frac{1}{8}$, of the circumference, instead of the semicircle BFM.

That the wing BNO may not act upon any part of the lever between A and C, the arm AC should be bent; and that the friction may be diminished as much as possible, a roller should be fixed upon its extremity C. When a roller is used, however, a curve must always be drawn parallel to the spiral described according to the preceding method, the distance between it and the spiral being every where equal to the radius of the roller.

When two or more wings are placed upon the circumference of the wheel, it has been the custom of practical mechanics to make them portions of an ellipsis, whose semi-transverse axis is equal to QD, the greatest distance of the curve from the centre of the circle. But it will appear from a comparison of the elliptical arch, with the spiral N, that it will not produce a uniform motion. If it should be required to raise the lever with an accelerated or retarded motion, we have only to divide the chord BC, according to the degree of retardation or acceleration required, and the circle into the same number of equal parts as before, and then describe the curve according to the method already laid down.

As it is frequently more convenient to raise or depress weights by the extremity of a constant radius, furnished with a roller instead of wings fixed upon the periphery of a wheel; we shall now proceed to determine the curve which must be given to the arm of the lever, which is to be raised or depressed, in order that this elevation or depression may be effected with an uniform motion.

Let AB, Fig. 8, be a lever, which it is required to raise uniformly through the arch BC, into the position AC by means of the arm or constant radius DE, moving upon D as a centre, in the same time that the extremity E describes the arch E e F. From the point C draw C H at right angles to AB, and divide it into any number of equal parts, suppose three, in the points 1, 2; and through the points 1, 2, draw 1a, 2b parallel to the horizontal line AB, cutting the arch CB in the points a, b, through which draw a A, b A. Upon D as a centre, with the distance DE, describe the arch E i e F, and upon A as a centre, with the distance AD, describe the arch e O D, cutting the arch E i e F in the point e. Divide the arches E i e. and F s e, each into the same number of equal parts as the perpendicular c H, in the points k, i, s, m, and through these points, about the centre A, describe the arches k z, i g, q r, m n. Take z x and set it from k to l, and take g f and set it from i to h. Take r q also and set it from s to t, and set nm from o to p, and d c from e to O. Then through the points E, l, h, O, and O, t, p, F, draw the two curves E l h O, and O t p F, which will be the proper form that must be given to the arm of the lever. If the handle DE move from E towards F, the curve EO must be used, but if in the contrary direction, we must employ the curve OF.

It is evident that when the extremity E of the handle DE, has run through the arch E k, or rather E l, the point l will be in k, and the point z in x, because x z is equal to k l, and the lever will have the position Ab. For the same reason, when the extremity E of the handle has arrived at i, the point h will be in i, and the point g in f, and the lever will be raised to the position Aa. Thus it appears, that the motion of the power and the weight are always proportional. When a roller is fixed at E, a curve parallel to EO, or OF, must be drawn as formerly.

It is upon these principles that the detent levers of clocks, and those connected with the striking part, should be formed. In every machine, indeed, where weights are to be raised or depressed, either by variable or constant levers, its performance depends much on the proper form of the communicating parts.

Hitherto we have supposed, that the wheel which carries the wipers or wings, moves in the same plane with the lever or weight to be raised. Circumstances, however, often occur, which render it necessary to elevate the lever by means of a wheel moving at right angles to the plane in which the lever moves; and when this

Mill Work.

Plate. 9.

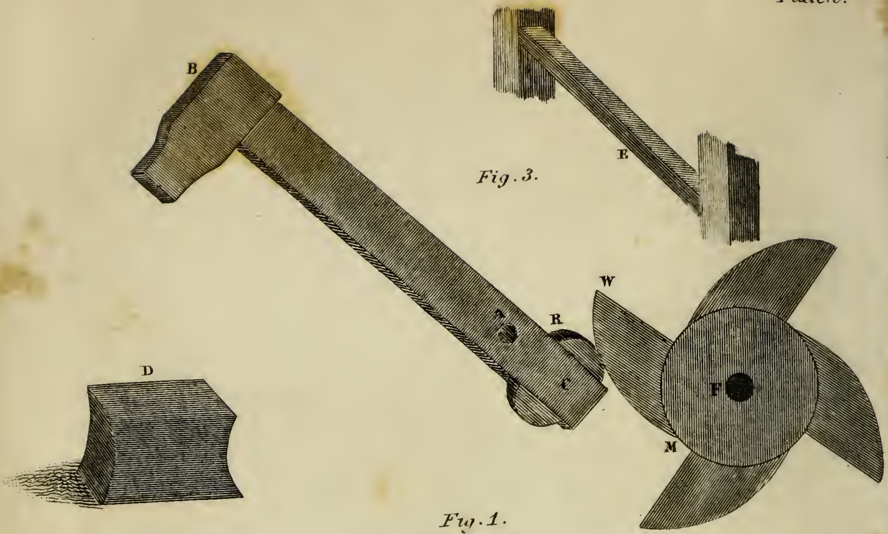
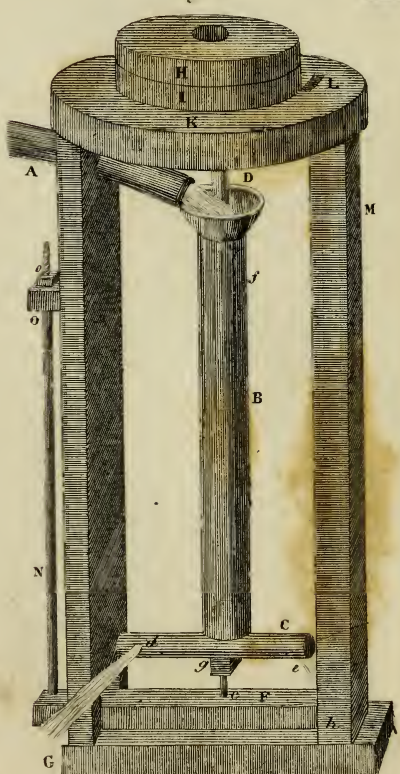


Fig. 3.

Fig. 1.



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method is adopted, a different form must be given to the wipers. As no writer on mechanics, so far as we know, has treated upon this subject, it becomes the more necessary to supply the defect by a few observations.

Let ABC, Fig. 10, Plate VIII. be the lever which is to be raised round the axis AD, by the action of the wing *m n* of the wheel D, upon the roller C, fixed at the extremity of the lever; it is required to find the form which must be given to the wiper *m n*. It is evident from Fig. 11, where CB is a section of the lever and roller, and BA the arch through which it is to be raised, that the breadth of the wiper must always be equal to *m n* or *r* B, the versed sine of the arch BA through which the roller moves, so that the extremity *n* of the wiper may act upon the roller B at the commencement of the motion, and the other extremity *m* may act upon the roller A, when the lever arrives at the required position CA. It is easy to perceive, however, that if the acting surface *m n* of the wiper be always parallel to the horizon, or perpendicular to the radii of the wheel, or the plane in which it moves, it will act disadvantageously, except at the commencement of the motion, when *m n* is parallel to CB. For when *m n* has arrived at the position *o p*, the extremity *o* will act upon the roller A, but in such an oblique and disadvantageous manner, that it will scarcely have any power to turn it upon its axis, or move the lever round the fulcrum C. The friction of the roller upon its axis, therefore, will increase, and the power of the wiper to turn the lever will diminish, in proportion to the length of the arch BA; and if CA arrive at a vertical position, the power of the wing will be solely employed in wrenching it from its fulcrum.

Having thus described the different methods of raising weights, whether perpendicularly, or round a centre, with a uniform velocity and force: it would be unnecessary to apply the principles of construction to those machines which are formed for the elevation of weights. The practical mechanic can easily do this for himself. There is one case, however, which deserves peculiar attention, because the wipers, formed scientifically, will not produce the intended effect. This happens in the large sledge-hammer which is employed in forges. In Fig. 3, Plate IX. BC is the large hammer moved round A as a centre, by means of the wiper MW acting upon its extremity AC, or upon the roller R. The hammer must be tossed up with a sudden motion, so as to strike the elastic oaken spring E, which, being compressed, drives back the hammer with great force upon the anvil D. Now, if spiral wipers, constructed according to the directions already given, are employed, the hammer will indeed be raised equably without the least jolting, but it will rise no higher than the wiper lifts it, and will therefore fall merely with its own weight. But if the wipers are constructed in the common way, and the hammer elevated with a motion greatly accelerated, it will rise much higher than the wiper lifts it; it will impinge against the oaken beam E, and be repelled with great effect against the iron on the anvil D. In any of the preceding constructions, this accelerated motion may be produced, merely by dividing BC according to the law of acceleration, and proceeding as already directed.

A water-mill, invented by Dr. Barker, that has neither wheel nor trundle.

This machine is represented by Fig. ,1 of Plate IX. in which *A* is a pipe or channel that brings water to the upright tube *B*. The water runs down the tube, and thence into the horizontal trunk *C*, and runs out through holes at *d* and *e* near the ends of the trunk on the contrary sides thereof.

The upright spindle *D* is fixed in the bottom of the trunk, and screwed to it below by the nut *g*; and is fixed into the trunk by two cross bars at *f*: so that, if the tube *B* and trunk *C* be turned round, the spindle *D* will be turned also.

The top of the spindle goes square into the rynd of the upper mill-stone *H*, as in common mills; and, as the trunk, tube, and spindle, turn round, the mill-stone is turned round thereby. The lower, or quiescent mill-stone is represented by *I*; and *K* is the floor on which it rests, and wherein is the hole *L* for letting the meal run through, and fall down into a trough, which may be about *M*. The hoop or case that goes round the mill-stone rests on the floor *K*, and supports the hopper, in the common way. The lower end of the spindle turns in a hole in the bridge-tree *G F*, which supports the mill-stone, tube, spindle, and trunk. This tree is moveable on a pin at *h*, and its other end is supported by an iron rod *N* fixed into it, the top of the rod going through the fixed bracket *O*, and having a screw-nut *o* upon it, above the bracket. By turning this nut forward or backward, the mill-stone is raised or lowered at pleasure.

While the tube *B* is kept full of water from the pipe *A*, and the water continues to run out from the ends of the trunk, the upper mill-stone *H*, together with the

trunk, tube, and spindle, turns round. But, if the holes in the trunk were stopped, no motion would ensue; even though the trunk and tube were full of water. For,

If there were no hole in the trunk, the pressure of the water would be equal against all parts of its sides within. But, when the water has free egress through the holes, its pressure there is entirely removed: and the pressure against the parts of the sides which are opposite to the holes, turns the machine.

On horizontal mills.—Although horizontal water-wheels are very common on the continent, and are strongly recommended to our notice by the simplicity of their construction, yet they have almost never been erected in England, and therefore are not described in any of our treatises on practical mechanics. In order to supply this defect, and recommend them to the attention of the mill-wright, we shall give a brief account of their theory and construction. In Fig. 1, of Plate X. we have a representation of one of these mills. *A B* is the large water-wheel which moves horizontally upon its arbor *C D*. This arbor passes through the immoveable mill-stone *E F* at *D*, and, being fixed to the upper one *G H*, carries it once round for every revolution of the great wheel. *N* is the hopper, and *I* the mill-shoe, the rest of the construction being the same as in vertical corn-mills.

The mill-course is constructed in the same manner for horizontal as for vertical wheels, with this difference only, that instead of being rectilineal, it must be circular, and concentric with the rim of the wheel, sufficient room being left between it and the tips of the float-boards for the play of the wheel.

The equipage of the millstone of a horizontal mill (which comprehends the millstone, the water-wheel, and its arbor) may be found by multiplying the product of the 100th part of the expense of the water in cubic feet, and the relative fall, by 5078, and the product will be the weight of the equipage in pounds avoirdupois.

The mean radius of the wheel *A B* is to be determined by multiplying the product of the relative fall, and the square root of the expense of water in a second by 0.062.

What has been said respecting the number, position, and form of the float-boards of vertical wheels, may be applied also to horizontal ones. In the latter, however, the float-boards must be inclined, not only to the radius, but also to the plane of the wheel, in the same angle in which they are inclined to the radius, so that the lowest and the outermost sides of the float-boards may be farthest up the stream.

Since the millstone of horizontal mills performs the same number of revolutions as the water-wheel; and since a millstone five feet in diameter should never make less than 48 turns in a minute, the wheel must perform the same number of revolutions in the same time; and in order that the effect may be a *maximum*, or the greatest possible, the velocity of the current must be double that of the wheel. Suppose the millstone, for example, to be five feet diameter, and the water-wheel six feet, it is evident that the millstone and wheel must at least revolve 48 times in a minute; and since the circumference of the wheel is 18.8 feet, the float-boards will move through that space in the 48th part of a minute, that is, nearly at the rate of 15 feet per second, which being doubled, makes the velocity of the water 30 feet, answering to a fall of 14 feet. But if the given fall of water be less than 14 feet, we may procure the same velocity to the millstone by diminishing the diameter of the wheel. If the wheel, for instance, be only five feet diameter, its circumference will be 15.7 feet, and its floats will move at the rate of 12.56 feet in a second, the double of which is 25.12 feet per second, which answers to a head of water less than ten feet high. As the diameter of the water-wheel, however, should never be less than seven times the breadth of the mill-course at *K*, there will be a certain height of the fall beneath which we cannot employ horizontal wheels, without making the millstone revolve too slowly. This height will be found by the following table.

When the natural depth of the water at the bottom of the fall is to the breadth of the mill-course at the same place, as	3 to 1	2 to 1	1 to 1 Equal.	½ to 1	⅓ to 1
The relative fall beneath which we cannot employ horizontal mills, will be	7.314	8.602	11.350	14.976	17.613
	ft. dec	ft. dec	ft. dec.	ft. dec	ft. dec.

Thus if the natural depth of the water at K, be three times the width of the mill-course at the same place, the relative fall beneath which we cannot employ a horizontal wheel will be 7.314 feet. Since the depth of the water is so great in this case, a great quantity of it will be discharged in a second, and therefore it requires a less velocity, or a less height of the fall, to impel the wheel; whereas, if the depth of the water had been only one third of the width of the mill-course, such a small quantity would be discharged in a second that we must make up for the want of water by giving a greater velocity to what we have, or by making the height of the fall 17.613 feet.

In order to find the radius of the millstone in horizontal mills, multiply the expense of water in cubic feet in a second, by the relative fall; extract the square root of the product, and multiply this root by 0.267, the product will be the radius of the millstone in feet.

The quantity of meal ground in an hour may be found by the rules already given for vertical mills, or by multiplying the product of the expense of water and the relative fall, by 456 lb. and the result will be the quantity required.

The thickness of the millstone at the centre and circumference, and the thickness of the arbor and pivots may be determined by the rules already laid down for vertical mills.

In horizontal wheels, the mill-course is sometimes differently constructed. Instead of the water assuming a horizontal direction before it strikes the wheel, as in the case of undershot-mills, the floatboard is so inclined as to receive the impulse perpendicularly, and in the direction of the declivity of the water-fall. When this construction is adopted, the greatest effect will be produced when the velocity of the floatboards is not less than $\sqrt{2\,a\,D}$; 2. Sin. A in which a represents the accelerating force of gravity $= 16.087$ feet, D the height of the waterfall, and A the angle which the direction of the fall makes with a vertical line. But since this quantity increases as the sign A decreases, it follows, that without taking from the effect of these wheels, we may diminish the angle A, and thus augment considerably the velocity of the floatboards, according to the nature of the machinery employed; whereas in vertical wheels there is only one determinate velocity, which produces a maximum effect.

In the southern provinces of France, where horizontal wheels are very generally employed, the floatboards are made of a curvilineal form, so as to be concave towards the stream. The Chevalier de Borda observes, that in theory a double effect is produced when the floatboards are concave, but that this effect is diminished in practice, from the difficulty of making the fluid enter and leave the curve in a proper direction. Notwithstanding this difficulty, however, and other defects which might be pointed out, horizontal wheels with concave floatboards are always superior to those in which the floatboards are plane, and also to vertical wheels, when there is a sufficient head of water. If the fall of water be five or six feet, a horizontal wheel with concave floatboards may be erected, whose maximum effect will be to that of ordinary vertical wheels as 3 to 2.

On double corn-mills.—In order to find the weight of the equipage for each millstone, multiply the product of the expense of water and the relative fall, by 4811.6 lb. and divide the product by 2000, if there be two millstones, by 3000, if three, and so on; the quotient will be the weight of the equipage of each millstone.

To determine the radius of the wheel that drives the trundles, find first the radius of the millstones by the rules already given, and having added it to half the distance between the two neighbouring millstones, [which quantity may be taken at pleasure, and should be never less than 2 feet, however great be the number of the millstones] subtract from this *sum* the radius of the lantern, which may be taken at pleasure, and the remainder will be the radius required, when there are two millstones. But when there are three millstones, or four, or five, or six, before subtracting the radius of the lantern, divide the sum by 0.864, 0.705, 0.587, or 0.5, respectively.

The mean radius of the water-wheel may be found by multiplying the square root of the relative fall by the radius of the millstone, by the radius of the wheel that drives the trundles, and by 231, and then dividing the product by the radius of the lantern multiplied by 1000, the quotient will be the wheel's radius. It may happen, however, that the diameter of the wheel found in this way will be too great. When this is the case, we may be certain that the radius of the lantern has been taken too small. In order then to get a less value for the wheel's radius, increase a little the radius of the lantern, and find new numbers both for the water-wheel, and that which drives the trundles, by the preceding rule. It may happen also that in giving an arbitrary value to the ra-

dius of the lantern, the diameter of the wheel found by the rule may be too small, that is, less than seven times the breadth of the mill-course at the bottom of the fall. When this takes place, make the diameter of the water-wheel seven times the width of the mill-course, and you may find the radius of the other wheel and lanterns by the following rules.

1. To find the radius of the wheel that impels the trundles; add the radius of the millstone to half the distance between any two adjoining millstones for a first quantity. Multiply the square root of the relative fall by the radius of the millstone and by .231, and having divided the product by the radius of the water-wheel, add unity to the quotient, and multiply the sum by 1. if there be two millstones, by .864 if three, by .705 if four, by .587 if five, and by .5 if six, and the result will be a second quantity. Divide the first by the second quantity, and the quotient will be the radius of the wheel that drives the trundles.

2. To find the radius of the lantern, multiply the radius of the wheel as found by the preceding rule, by the square root of the relative fall, and by .231, and divide the product by the radius of the water-wheel, the quotient will be the lantern's radius.

By the rules formerly given find the quantity of meal ground by one millstone, and having multiplied this by the number of millstones, the result will be the quantity ground by the compound mill.

If the equipage of the millstone of a vertical mill should be too great, that is, if it should require too large a millstone, then we must employ a double mill, or one which has more than two millstones.

In order to know the equipage of each millstone, find it by the rule for a single mill, and having multiplied the quantity by .947, divide the product by the number of millstones, and the quotient will be the equipage of each millstone.

On breast-mills.—A breast water-wheel partakes of the nature both of an overshot and of an undershot wheel: it is driven partly by the impulse, but chiefly by the weight, of the water. The effect of a mill driven in this manner, is equal, according to Mr. Smeaton, 'to the effect of an undershot mill, whose head is equal to the difference of level between the surface of water in the reservoir and the point where it strikes the wheel, added to that of an overshot, whose height is equal to the difference of level between the point where it strikes the wheel and the level of the tail-water.' M. Lambert observes, that a breast-wheel should be used when the fall of water is above four feet, and below ten, provided the discharge of water be sufficiently copious; that an undershot wheel should be preferred when the fall is below four feet, and an overshot wheel, when the fall exceeds ten feet; and that, when the fall exceeds 12 feet, it should be divided into two, and two breast-mills erected. This, however, is only a general rule, which many circumstances may render it necessary to overlook. The following table, which may be of essential utility to the practical mechanic, is calculated from the formulæ of Lambert and exhibits at one view the result of his investigations.—

TABLE FOR BREAST-MILLS.

Height of the fall in feet. = *CD*, Fig. 1.	Breadth of the float boards. Ft. Dec.	Depth of the float-boards. Ft. Dec.	Radius of the water-wheel reckoned from the extremity of the floats. Ft. Dec.	Velocity of the wheel per second. Ft. Dec.	Time in which the wheel performs one revolution. Secs. Dec.	Turns of the mill stone for one of the wheel.	Force of the water upon the float-boards. lbs. Avoir.	The length of *m n* in Fig. 1. Ft. Dec.	The length of *n o* in Fig. 1. Ft. Dec.	Water required per second to turn the wheel. Cub. Ft.
1	0.17	198. 6	0.75	2.18	1.92	4.80	1536	0.08	0.23	74.30
2	0.34	35. 1	1.50	3.09	2.72	6.80	1084	0.15	0.46	37.15
3	0.51	12. 7	2.26	3.78	3.33	8.32	886	0.23	0.68	24.77
4	0.69	6. 2	3.01	4.36	3.84	9.60	768	0.30	0.91	18.57
5	0.86	3.57	3.76	4.88	4.28	10.70	686	0.38	1.14	14.86
6	1.03	2.25	4.51	5.35	4.70	11.76	626	0.46	1.37	12.38
7	1.20	1.53	5.26	5.77	5.08	12.70	581	0.53	1.60	10.61
8	1.37	1.10	6.02	6.17	5.43	13.58	543	0.60	1.83	9.29
9	1.54	0.81	6.77	6.55	5.76	14.40	512	0.68	2.05	8.26
10	1.71	0.77	7.52	6.90	6.07	15.18	486	0.76	2.28	7.43
1	2	3	4	5	6	7	8	9	10	11

Plate 10.

Fig. 1.

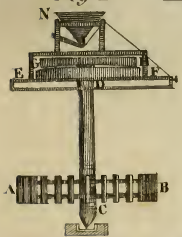


Fig. 5.

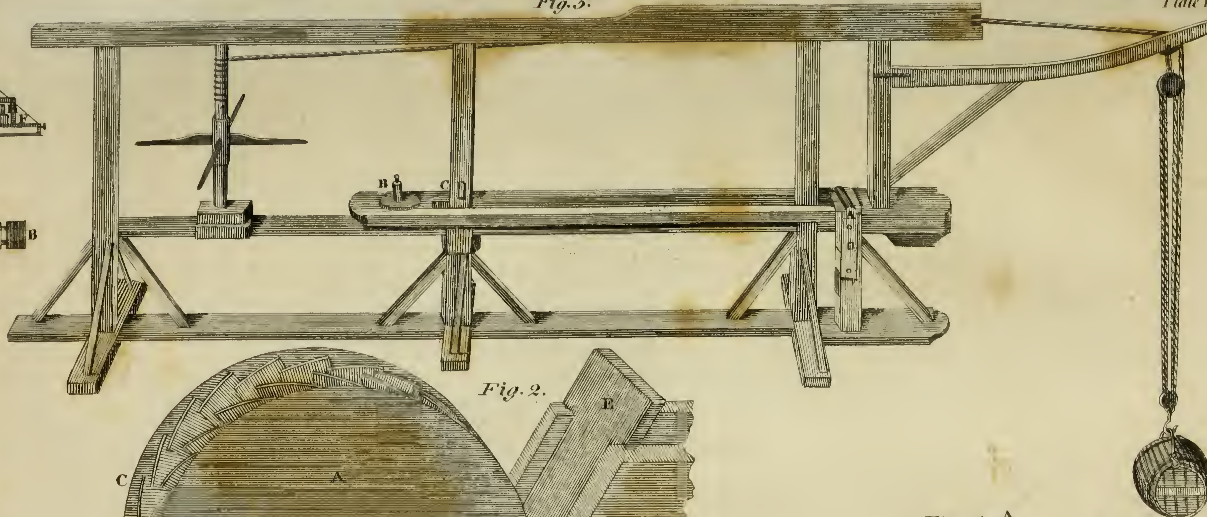


Fig. 3.

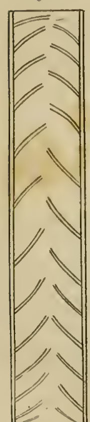


Fig. 2.

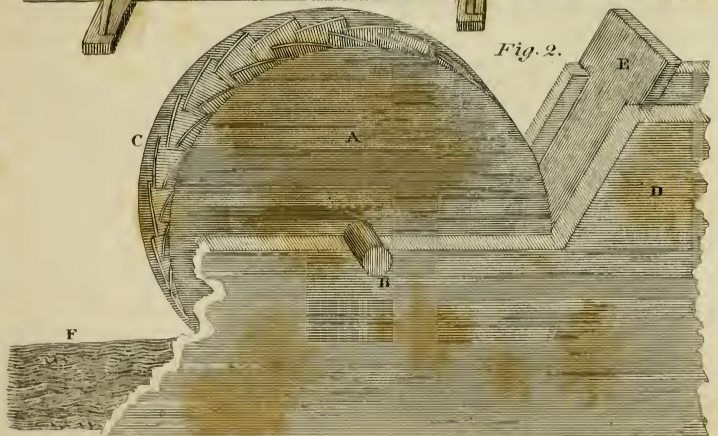
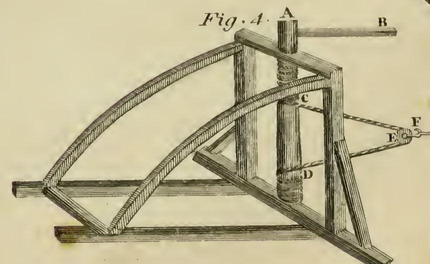


Fig. 4.



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It is evident from the preceding table, that, when the height of the fall is less than 3 feet, the depth of the floatboards is so great, and their breadth so small, that the breast-mill cannot well be employed; and on the contrary, when the height of the fall approaches to ten feet, the depth of the floatboards is too small in proportion to their breadth. These two extremes, therefore, must be avoided in practice. The last column contains the quantity of water necessary for impelling the wheel, but the total expense of water should always exceed this, by the quantity, at least, which escapes between the mill-course and the sides and extremities of the floatboards.

Descripiton of a water-wheel. By Mr. J. Besant.

Sir—I beg leave to lay before the Society for the Encouragement of Arts, some observations respecting the common undershot water-wheel, and to point out the superiority of that of my invention.

1. In common water-wheels more than half the water passes from the gate through the wheel, without giving it any assistance.

2. The floats coming out of the tail-water are resisted with almost the whole weight of the atmosphere, at the instant they leave the surface of the water.

3. The same quantity of water which passed between the floats at the head, must of course pass between them at the tail, and consequently impede the motion of the wheel.

In the water-wheel of my invention,

1. No water can pass but what acts, with all its force, on the extremity of the wheel.

2. The floats coming out of the water in an oblique direction, prevent the weight of the atmosphere from taking any effect.

3. Although the new water-wheel is heavier than that on the old construction, yet it runs lighter on its axis, the water having a tendency to float it.

4. By experiments made with the models, proofs have been shown, that the new wheel has many advantages over the common wheel, and that, when it works in deep tail water, it will carry weights in proportion of three to one, so that it will be particularly serviceable for tide-mills.

I hope on trial, before the society, my invention will prove successful.

Repeated experiments of the above invention were made by the committee; from the result of which it appeared to possess some advantages over the common wheel, and to have a greater power of action.

Drescription of the late Mr. Besant's water-wheel. Plate X. Figs. 2 and 3.

A. The body of the water-wheel, which is hollow in the form of a drum, and is so constructed as to be proof against the admission of water within it.

B. The axis on which it turns.

C. The float boards placed on the periphery of the wheel. Each board is obliquely fixed firm to the rim of it, and to the body of the drum.

D. The reservoir, containing the water.

E. The penstock, which regulates the quantity of water running to the wheel.

F. The current of water which has passed the wheel.

Fig. 2. Is a front view of the water-wheel, showing the oblique direction in which the float-boards C are placed on the face of the wheel.

Description of a simple and powerful capstan.

This capstan is represented in Fig. 4. Plate X. where AD is a compound barrel consisting of two cylinders CD of different radii. The rope DEC is fixed at the extremity of the cylinder D, and after passing over the pulley E, which is attached to the load by means of a hook F, it is coiled round the other cylinder C, and fastened at its upper end. AB is the bar by which the compound barrel CD is urged about its axis, so that the rope may coil round the cylinder D while it unwinds itself from the cylinder C. Let us now suppose that the diameter of the part D of the barrel is 21 inches, while the diameter of the part C is only 20, and let the pulley E be 20 inches in diameter. It is evident then that when the barrel AD is urged round by a pressure exerted at the point B, 63 inches of rope will be gathered upon the cylinder D, and 60 inches will be unwinded from the cylinder C by one revolution of the bar AB, these numbers representing the circumference of each cylinder. The quantity of wound rope, therefore, exceeds the quantity that is unwound by 63—60, or 3 inches, the difference of their respective perimeters; and the half of this quantity, or 1½ inch will be the space through which the load or the pulley E moves by one turn of the bar. But if a simple capstan of the same dimensions had been employed, the length of rope coiled round the barrel by one revolution of the bar would have been 60 inches, and

the space described by the pulley or load to be overcome would have been 30 inches. Now, it is a maxim in mechanics, that the power of any engine is universally equal to the velocity of the impelled point divided by the velocity of the working point, or to the velocity of the power divided by the velocity of the weight; that is, to the velocity of the point B divided by the velocity of the pulley E; consequently if the lever in both capstans be the same, and the diameter of their barrels equal, the power of the common one will be to the power of the improved one as $1\frac{1}{2}$ to 30, that is, inversely as the velocity of their weights, and the power of the latter will be $\frac{30}{1.5} = 20$, or in other words, will be equivalent to a 20 fold tackle of pulleys. If it be wished to double the power of the machine, we have only to cover the cylinder C with laths a quarter of an inch thick, so that the difference between the radii of each cylinder may be half as little as before; for the power of the capstan increases as the difference between the radii of the cylinders is diminished. As we increase the power, therefore, we increase the strength of our machine, while all other engines are proportionably enfeebled by an augmentation of power. Were we, for example, to increase the power of the common capstan, we must diminish the barrel in the same proportion, supposing the bar or handspike not to admit of being lengthened, and we not only weaken its strength, but destroy much of its power by a greater flexure or bending of the ropes.

The reader will perceive that this capstan may be converted into a crane or windlass for raising weights, merely by giving the compound barrel AB a horizontal position, and substituting a winch instead of the bar AB. The superiority of such a crane above the common ones is obvious from what has been said; but it has this additional advantage, that it allows the weight to stop at any part of its progress without the aid of a ratchet wheel and catch, from the two parts of the rope pulling on contrary sides of the barrel. The rope, indeed, which coils round the larger part of the barrel acts with a larger lever, and consequently with greater force than the other; but as this excess of force is not sufficient to overcome the friction of the gudgeons, the weight remains stationary in any part of its path.

A crane of this kind was erected in 1797, at Bordentown in New Jersey, by Mr. M'Kean for the purpose of raising logs of wood to the frame of a saw mill, which was 10 feet distant from the ground. The diameter of the largest cylinder was 2 feet, and its length 3 feet; the other cylinder was 1 foot in diameter, and of the same length with the largest. The difference of their circumferences, therefore, was 3 feet, and the log would move through a space of 18 inches with one turn of the handspike; and through the required height with only 8 turns. The length of the bar or handspike was 6 feet, which, at the point where the power was applied, described a circle of about 30 feet, so that the power of the crane was as 1 to 20. The length of the rope was only 55 feet, whereas if the weight had been raised through the same height with a similar power by means of a tackle of pulleys, 270 feet of a rope must have been employed. In the latter case, however, the rope sustains only one twentieth of the weight, but in the former it supports one half of the load.

In describing a capstan of this kind, Dr. Robison asserts, that when the diameters of the cylinders which compose the double barrel are as 16 to 17, and their circumferences as 48 to 51, the pulley is brought nearer to the capstan by about 3 inches for each revolution of the bar. This however, is a mistake, as the pulley is brought only $1\frac{1}{2}$ inch nearer the axis. This will be evident, if we conceive a quantity of rope equal to the circumference of the larger cylinder to be winded up all at once, and a quantity equal to the circumference of the lesser one to be unwinded all at once. In the present case, 51 inches of rope will be coiled round the larger part of the barrel by one revolution of the capstan bar, and consequently the load would be raised $5\frac{1}{2}$ feet, the rope being doubled Let 48 inches of rope be now unwinded from the lesser cylinder, and the load will sink 24 feet; therefore, $25\frac{1}{2}-24 = 1\frac{1}{2}$ foot is the whole height or distance through which the weight has been moved.

Dr. Robison affirms that the capstan now described was invented by an untaught but ingenious country tradesman. It appears, however, to be the invention of the celebrated George Eckhardt, and likewise that of the late Mr. Robert M'Kean of Philadelphia, son of the late governor of Pennsylvania.

Description of Mr. A. Andrews's Crane.

The proportion of the beam in Fig. 5, Plate X. is as 1 to 20, the large weight being five pounds, and the smaller one fourth of a pound. The latter, when fixed on

pound. The latter, when fixed on the beam-end, will equipoise the former, if hung on the pulley at the end of the gib-beam, which should be placed in a right line with the crane, at the same time the weight is adjusted; otherwise it will occasion a friction that may prevent the moveable beam from playing freely.

The gib of the crane stands on a horizontal beam, moveable on a centre, at A; (Plate X. Fig. 5.) and the distance of the centre A, from the bearing of the upright, being to the distance B, in the proportion of 1 to 20, the weight placed at B, determines that of the body suspended in the same proportion. C is a stub, or piece of wood, which projects from the weight hanging at the end of the gib, and serves to prevent the beam from rising to too great a height.

One of the latest improvements in this useful machine, is that proposed by the Rev. E. C. in the 2d vol. of the Repertory of Arts and Manufactures.

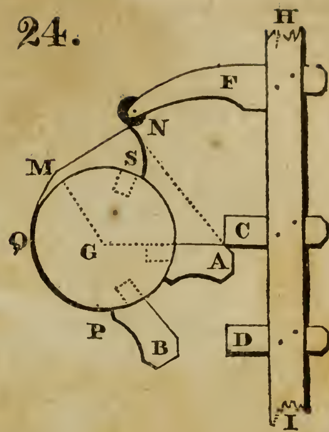
Description of a method of lifting forge hammers, or stampers for rice, plaster of Paris, &c. without noise or percussion. By Mr. John Garnet, of New Brunswick, New Jersey, in a letter tp Dr. James Mease.

When heavy stampers are to be raised, in order to drop on the matters to be pounded, a stroke or percussion is given, that shakes the supporting frame, deranges in a little time the machinery, and causes that deafning noise from stamping and fulling-mills heard at a considerable distance.

To remedy this, I have used with success, the following method, which first overcomes the vis inertiæ of the stampers, by gradual acceleration, until the required velocity is attained, and then continues this velocity uniformly to any required height of the stamper. Thus,

Let HI (24) be a stamper in a vertical position, on which are fixed the spurs C, D, and slider or sheeve N. GPQ the section of a shaft or barrel, placed horizontally to lift the stamper by means of a wiper MNS lifting the slides FN, and teeth and tappets AB, acting on the spurs C, D; for as the barrel G revolves, the slider or sheeve N will slide or roll along the plane MN to the point N, where it will have given the stamper HI the precise vertical velocity of the pitch line of the teeth or tappets AB on the barrel; these teeth will then continue the velocity to any required height, according to their number and pitch.

24.



To construct the Wiper, M N S.—From the point G the centre of the shaft, and A the pitch point of the first tooth or tappet draw any two parallel lines G M, A N, but not exceeding 30 degrees from the vertical, or making the angle G A N not less than 60 degrees; then any convenient line M N at right angles to, and joining these parallel lines; will give the length and position of the *wiper*.

Or a workman may be directed to place a carpenter's common iron square A N M on the point A, the pitch of the first tooth, at an elevation of not more than 30 degrees from the vertical (G A being horizontal) then the part N M of the square will mark the required wiper. It is easy to demonstrate, (and may be a neat problem for some of your mechanical correspondents) that the point N of the wiper will give the same vertical velocity to the stamper H I as the pitch line of the teeth or tappets. The wiper may be in the same or a different plane from the teeth A B, as circumstances may require.

To give an example in numbers, the following would be found convenient for a stamper to be raised 18 or 20 inches:—

G A = 14 inches; G M = $10\frac{1}{2}$; G N= $16\frac{1}{25}$ (which distances from the centre G, can be found by revolving the shaft) then A N will be $17\frac{1}{2}$ inches and M N $12\frac{1}{8}$. which can readily be marked by placing a carpenter's square A N M on the point A to N $17\frac{1}{2}$ inches, and drawing the line N M on the *wiper*.

Description of a Screw Press, with an expanding Power, by Mr. Wm. Bowler.

The screw and spring-press which I have the honour to present to the inspec-

tion and for the approbation of the Society for the Encouragement of Arts, &c. will, I trust, be found in a superior degree adapted to the purpose of pressing bodies in general, but more particularly cheeses, apples, linen, &c. because such things require a firm and unrelaxing pressure:—and this is a peculiar advantage incident to this machine; for after it is set, or the spring screwed well up, it will be found, that as the *article* pressed shrinks from it, so the spring, owing to its peculiar expanding power, gradually follows the object of its pressure, and hence continues to maintain an uniform and equal action on the body on which it is placed. This, in cheese-making, will be found peculiarly advantageous; for, it is from this very cause of want of sufficient pressing that cheeses are frequently so very bad. Were the curd entirely separated from the impure and contaminating mixture of the whey, which must be effected by the regular action of this machine, we should always have the cheese firm and wholesome; and, I have not a doubt, the press will be found equally useful in all other cases, and answer every purpose, even beyond expectation, to which it is adapted.

Reference to the Engraving, Plate 11. *Fig.* 1.

AA, the two upright sides, or frames of the press.

B, the cross piece which connects them at the top, having a hole in its centre, for the screw.

C, a strong block of wood, into which the two sides of the press are firmly mortised.

D, the box, in which the article to be pressed is placed. This box has a number of holes in its bottom, through which the liquid matter when pressed out passes, and is discharged from the mouth of the spout E, a small hollow being left under the box, to allow its passage to the spout. A loose wooden cover fits into the box D, and upon it is fastened a stout piece of timber F, and an iron plate G, for the point of the screw of the press to act upon.

H, the male screw of the press, working in a female screw in the centre of the strong cross piece I, which cross piece slides up and down in grooves within the two sides of the frame, one of which grooves is shewn in the plate, and about half the length of the side piece.

K, the upper part of the iron screw, on which the handle L, which moves it, is placed upon a square. The iron of the screw is only wormed about half its length.

M, a strong spiral spring, made of iron wire, or iron rod, placed in the centre of the cross pieces B and I; this spring presses downwards against the cross piece I, forcing it as low down as the side grooves will permit. The male screw H lies within the circle of this spiral; and, when the screw is turned, passes through the female screw below it, and acts upon the iron plate G, under which the matter to be pressed is placed, by continuing to turn the screw. As it meets with resistance at the point G, it gradually forces back the cross piece I, by means of the female screw within it, and compresses the spiral into a small space, between the two cross pieces, in which state it remains, till the article which is pressed in the box begins to give out a part of its contents. The spiral spring M, compressed as abovementioned, then begins to expand, and exerts a continued re-action upon the cross piece I, on the male screw H, the iron plate of which covers the article under pressure.

The other figure is the male screw, separated from the other parts, to shew how far the thread or worm extends upon it.

Machine for grinding Colours, from the Transactions of the Society for the encouragement of Arts, &c.

Mr. James Rawlinson, of Derby, presented a model of this machine to the Society of Arts, for which he received the silver medal and ten guineas. He used the machine for several years, and has found it much more effectual and expeditious in reducing the colours to extreme fineness, than the usual method, and much less injurious to the health of the workmen, who frequently have done as much with it in three hours as they could in twelve with the muller and slab.

The machine consists of a flat cylinder of black marble, sixteen inches and an half in diameter, and four and an half in thickness, with an axle traversing its centre (thus somewhat resembling a common cutler's grind-stone.) fig. 2. plate XI. It is suspended on a similar frame, in a vertical position, and turned round in the same manner by a winch; a concave piece of marble is provided of the same breadth as the circular stone, forming a segment of the same circle one third of the circumference in extent. This, which may be considered as the muller, is fitted into a piece of solid wood of similar shape, one end of which is secured loosely by a hinge, or otherwise to the frame; the other end rising over the circular stone and supported by it, is further pressed down

Plate. 11.

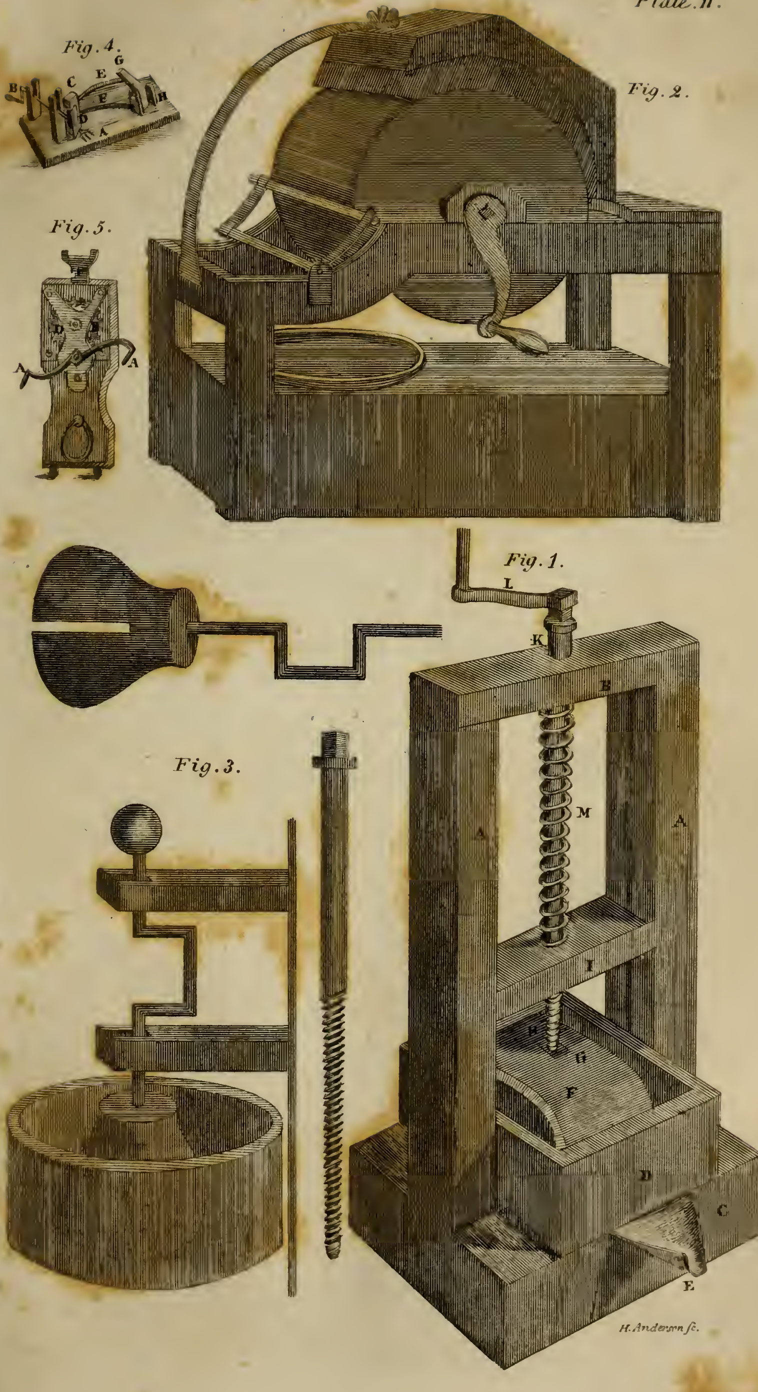


Fig. 4.
B C E G F D A H
Fig. 5.
F D B A A
Fig. 2.
Fig. 1.
L K B M A A I H G F D C E
Fig. 3.
H. Anderson sc.

on it by a long spring, bent over from the opposite extremity of the stand, and regulated, as to its pressure, by a screw, whose end turns against the concave muller; a slight frame of iron in front, moveable on a hinge, by which it is secured to the frame, supports a scraper for taking off the colour, formed of a piece of watch spring, which is turned back out of the way when not in use.

Mr. Rawlinson thinks that the circular grindstones might be made much large than that he used, to advantage, and that one of two feet diameter would not occasion too much labour for one man to turn it. He computes, that in his machine, there are seventy square inches of the muller in constant work on the paint, while in the common muller, not more than sixteen square inches are usually in contact with the slab. The machine will be found equally serviceable for the colours ground in water, as for those prepared with oil, according to Mr. Rawlinson, who highly recommends its use to all colourmen.

Mr. Rawlinson advises to make up the colours in bladders, and to insert a bit of quill or reed in the neck of the bladder, which will thus bind better in tying; and admitting of a secure stopper, will be more cleanly and less wasteful than the usual method of stopping by a nail, and keep the colour more safe from the air.

Machine for grinding indigo and dry colours. Fig. 3, Plate XI.

This machine consists of a mortar, in which it revolves by a handle, a pestle, or muller, which is slit in the middle in order to faciliate the grinding, by changing the position of the indigo, or other colour, during the operation. The figure represents the different parts.

Coats' Machine for paring Apples.

The apple is fixed on the three pronged fork A, Fig. 4, Plate XI. and is turned by the handle B. To the block C, the knife D is fastened in the manner of a spoke share. E and F are springs which fasten the knife to the piece G, turning on a pin at H, while the right hand turns the handle B, the left presses against the springs E F, and turns the knife in a semicircle over the apple. Dr. Mease has tried the experiment with this machine, and found it to pare apples with great rapidity.

Description of Mr. Mocock's Improved Machine for raising large weights.

A A, Fig. 5, Plate XI. are the double handles of the winch.

B, represents the large toothed wheel, in which the pinion on the axis C works.

D, a ratchet-wheel.

E, the clink, or pall, which falls into the teeth of the ratchet, and thus prevents the machine from running back, in case the weight should at any time overcome the power.

F, the rack, as appears in jacks of the common construction.

From a comparison of Mr. Mocock's jack with those in common use, the former differs from the latter only in one respect; namely, that, in the improved machine, a pall, or chick, and ratchet, are applied in such a manner as to stop the machine in the case abovementioned, and thus to prevent those melancholy accidents which frequently occur, especially on board of ships engaged in action; when, from inattention, or neglect in fixing the hooks, or from any other cause, the common jacks fail: and, as the difference in its mechanism is not material, the improvement may be easily applied to the instruments already manufactured.

Mr. Terry's Mill, Fig. 1, Plate XII.

In the 19th vol. of the Transactions of the London Society of Arts, (1801), Mr. Garnet Terry, of London, describes a hand-mill for grinding hard substances, which is simple in its construction, and may be applied to a variety of useful purposes. The front of the mill is taken off, in order to shew its interior construction.

DESCRIPTION.

A, The hopper, the receptacle of the articles which are intended to be ground.

B, A spiral wire, in the form of a reversed cone, to regulate the delivery of them.

C, An inclined iron plate, hung upon a pin on its higher end: the lower end rests on the grooved axis D, and agitates the wire B.

D, the grooved axis, or grinding cylinder, which acts against the channeled iron-plate E.

F, A screw on the side of the mill, by means of which, the iron-plate E, is brought nearer to, or removed further from the axis D, according as the article is wanted finer or coarser.

G, the handle, by which motion is given to the axis.

H, The tube, whence the articles, when ground, are received.

Mr. Terry says, he has made one on a large scale, and finds it answers the purpose of reducing to powder, coffee, bones, beans, peas, malt, barley, &c.

Dearborn's Balance, of which the following is a description.

Fig. 2, of Plate XII. is a representation of that part of Dearborn's balance in which the pivots are placed—*a* is the centre of motion, on which the beam turns; *b* is the point where the article to be weighed is suspended; and c is the point where the poise is suspended, both being on a line with the centre of motion. While the beam remains level, the horizontal distances of these points of suspension are *a b* and *a* c; depress the larger end of the beam, until the point *b* falls to *d*, and the point c will rise to *e*; it is evident, that the horizontal distances are both reduced, and that this reduction of distances on both sides the centre of motion, is always equal or proportional. Thus, by placing the points of suspension on a line with the centre of motion, by fixing the centre of motion above the centre of gravity, and by making the arms of the beam in counterpoise, it preserves its vibrations when light or loaded, and hence the reasons why no art in management can render it a fraudulent instrument.

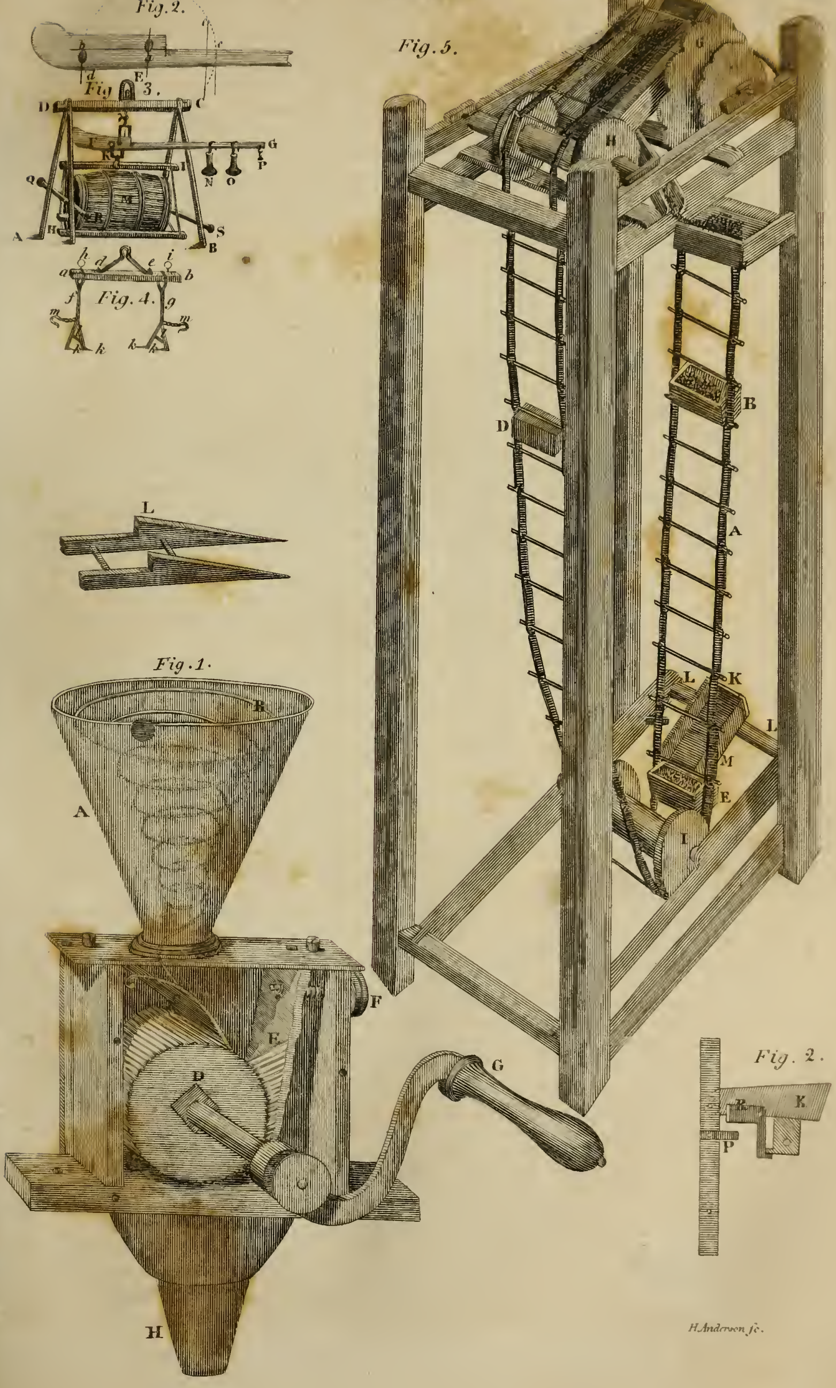
Fig. 3, represents the balance with its apparatus. ABCD is a wooden frame, with an iron screw at E, on which the beam FG is suspended. The scale HI is attached to the beam by the clasp K, which slides on the bar KI, to be moved over the centre of the weight in the scale; the skid L is formed to receive the scale on one end, while the other end answers as an inclined plane, over which the cask M is rolled into the scale. When the scale is to be charged, it is fixed at a proper height, by turning the screw E until the scale will rest fairly on the skid, when the beam is elevated to an angle of 30 or 40 degrees above a horizontal line. The little weight P (called the balance weight) is a brass case, into which a sufficient quantity of shot is put, to produce an exact equipoise with the scale; if the weight of the scale varies by any cause the shot is augmented or diminished accordingly, for which purpose the top of the brass case has a small screw to be taken out for making the change. The scale, when charged, rests on the skid, by which it is kept out of the mud, and at a suitable distance from the ground; the small end of the beam is then brought down by hand, which raises the scale and relieves the skid, if the weight in the scale be nearly under the clasp; if not, the beam is raised until the scale rests again on the skid, and the clasp is loose, which is moved by hand over the weight. The beam being again brought down, the poises NO are put on, and the skid is drawn out; when the poises are so placed as to produce a level beam, the two numbers being added, at which the poises hang, will give the weight of the article. The handles QR and S, are for lifting the apparatus by hand, and transporting it small distances, without the trouble of taking it apart. T is a guard, which is useful when the scale is to be many times charged with a given weight of small articles, in which case the beam may rest in the guard, without taking off the poises, until all the draughts are weighed. The principles on which this balance is predicated, require that the larger poizes or weights attending it, shall be multiples of the smaller, therefore the following are the sizes, viz. 1lb. 2lb. 4lb. 8lb. 16lb. and 32lb. and the two sides of a beam may be graduated for any two of those weights, and may be sufficiently strong, for bearing any number required, for the largest draughts. Under or near the beginning of the graduated edge of every beam, on each side, is stamped the weight of the poise, for which the respective side is marked, and in all possible variations of the weights, any article will be found to weigh alike, when weighed with the heavier weight alone, or the lighter weight alone, or with both together, or with any greater number which will produce an equipoise; hence arises an incontrovertible testimony of the accuracy of the system, and of the construction of the balance.

Balances of a small size are made for domestic purposes, and for shop-counters, which are found exceedingly convenient, when a tin scale is attached to the lower hook, and may be rendered more peculiarly so, by the addition of another scale, at sixteen times the distance from the centre, for weighing ounces.

Fig. 4, is a representation of a grapnel for weighing casks and boxes with the balance, without removing them from the spot: *a b* is a bar of wood with holes, described by the black spots: *c* is an iron by which the grapnel hangs to the balance; it is secured to the bar by the bolts *d e*: *f g* are two irons, kept at proper distances by the bolts *h i*: *kkkk* are four points about three inches in length, which are entered under the ends of the cask or box, and lift it by the draught of the beam. The two points of each iron are kept about one foot apart, by the little bolts *l l*: *m m* are two hooks, fastened by a few links to the irons; these hooks, being thrown over the bars QR and S, in Fig. 3, keep the two irons separate, a sufficient distance for setting the apparatus over the next cask, without interference. The height

Mr. T. Arkwright's Machine for raising Ore from Mines.

Plate 12.



H. Anderson sc.

of the whole should be nearly the height of a scale for weighing hogsheads, like that represented in Fig. 3, that either the grapnel or the scale may be used with the same frame. With this apparatus, but two assistants are necessary for weighing any number of casks, as the frame, with its appendages, is moved from one to another, and set over them in rotation, by two persons, with much less labour than would be necessary for removing a heavy cask. See BALANCE.

Of the pedometer, or *odiometer*.—The pedometer is a contrivance for measuring distances, which is usually in the form of a watch with wheels, teeth, &c. They are used by being fastened to a string, chain, &c. to the knee of a person, or to a wheel of a carriage. They advance one notch at a step, or each turn of the wheel. By the number being marked on a dial plate, the traveller may compute his progress, or measure the distance from place to place. There are various constructions of this instrument; some, therefore, mark the hour as well as the distance. These are generally small. Pedometers, on a larger scale, are used also in surveying lands. Mr. Edgeworth has contrived one for this purpose. The following is a description of a pedometer invented by Mr. Tugwell, Plate III. Fig. 5.

A, The stock of the pedometer.

B, B, B, &c. Twelve spokes; one end of which is fastened by means of a screw to the outward ring, or periphery of the wheel, while the other is inserted in the stock.

C, The periphery, which is an iron ring 16½ feet, or one pole in circumference; and which is divided into 25 equal parts, corresponding to the links of Gunter's chain for land-measuring, &c.

D, D, D, &c. Are twelve small plates, representing the separate spokes, and each of which includes two links of the chain above-mentioned; the twelfth spoke being divided at its foot, for comprehending the 25th link.

E, An iron axis, being a screw with 320 circumvolutions, each of which is marked separately on an engraved index on one of its sides: and, in order to apply this part of the machine, it is screwed firmly into the stock of the wheel, with which it revolves when in motion.

F, A style, or alidade, being an expanding screw-nut, that embraces the axis, along which it screws, as the latter revolves with the wheel; and, as each revolution describes an exact longitudinal pole (four of which are computed to a chain) the style being pendent, and moving towards its proper figure, denotes the length of ground passed; as it is divided into chains and poles on the index of the axis E, and into links on the periphery C.

G, is a small adjusting screw; which being turned, the style may be removed to the beginning of the index, after the given line, in surveying or measuring land, has been ascertained in chains, poles, &c.

H, represents a cross, or square, with sights, for determining perpendiculars in land-measuring. It is suspended at its ends on the axis, whence it may be occasionally detached by a simple touch of the finger and thumb, when in use. Farther, this cross prevents the style from being revolved with the axis by any accident. As the 320 divisions marked on the index of the axis E, describe a mile, the style F, after having passed over them, will stop: and, as it will now move round with the axis, it will carry with it the standard; which will strike on the wrist of the operator, and thus prevent him from proceeding to any farther distance, till he withdraws his hand from between such standard and the axis. Having received this hint, he turns the screw G; puts the style F back to the bottom of the index, and continues the revolution of the machine, till he has completed his course.

Mr. Tugwell's contrivance is particularly calculated to prevent error in measuring land; as one person may thus survey with greater accuracy and expedition, than by the use of the chain alone. Besides, no fraud can possibly be committed by labourers, in measuring task-work; a circumstance of the utmost importance to agriculturists.

Screw press for packing.—Our friend WILLIAM S. SIMMONS Esq. politely furnished us with a drawing of this important invention, with the following description, which, from its usefulness, may be considered a valuable application of the principle of the screw. It is a patented invention [by one of his family,] of which some notice was taken in vol. i. The machine being in operation, may be considered as adequate to the purposes herein after mentioned.

"It is used," says Mr. W S. Simmons, "for the purpose of packing cotton, sarsaparilla, tobacco stems, flax, hemp, peltries, quercitron bark, and in fact, any articles that will bear pressure." He adds, "that this machine would be very useful to the United States, for packing clothes, blankets, and any articles that would occupy a great bulk." The following is a description, Plate III. Fig. 6.

A, Upright pieces.
B, Packing beam.
C, Top beam.
D, The follower.
E, The pressing piece.
F, Lever.
G, A windlass for drawing the hoops or ropes.
H, Pedestals supporting the machine.
I, Shaft passing through top beam.
K, Screws,
L, Wheels.
M, The box.
N, The bale as it appears when relieved from the box.

The operation of packing, after the article is prepared, consists in putting it into three boxes, arranged one on the top of the other; after they are filled with cotton, they are drawn by means of a tackle under the pressing piece of the machine, which is then put in operation. After the pressing piece passes through box No. 1, and enters box No. 2, it is then relieved from No. 1, by taking off its side; it then passes through box No. 2 in the same manner. The iron hoops are then passed through the holes on the bottom of the pressing piece, and, by means of the windlass, are drawn sufficiently tight, and rivetted. The machine is then relieved from the bale.

Machine for cutting wood screws, invented and patented by R. Hancock sen. and Edward W. Carr, of Philadelphia. Plate XIII.

Mr. Carr favoured us with a drawing of the machinery and a specification of the patent, of which the following is a description.

The improved screw cutter, for cutting all kinds of screws as far as it can be applied, is a lathe consisting of a wheel or drum, pullies and spindle, and poppets that carry the spindle; a bench of cast iron, to which is attached the poppets DD, also the frames HH that support the pivots, which screws, regulates, and governs the clams EF. The machine more particularly consists in the construction of the spindle, regulating screws and clams; and the cutters for forming the regulating screws that are cut. The spindle AA is formed with a socket at each end; on the centre of the spindle between the poppets is two pullies OO, and the band PP is changed from one to the other by the handle at M, which stops or gives motion to the spindle at pleasure. At one end of the spindle is a regulating screw, which is changed as circumstances require, to which is applied clams F, with lever and spring I. At the other end is the socket A, and sliding spring BB holding the pin C to be cut. When the pin to be cut is put into the socket A, and secured from moving in the socket by the end of the spring BB entering the slit in the head of the pin; then the levers N and K are lifted up so as to move the joints JJ, which gently shut the clams E and F; at the same instant the clam F takes hold of the regulating screw, the clam E seizes the pin to be cut between two points of the cutter, which are fitted in four directions, the single and one double; the double is notched in the end so as to form the screw with a true, smooth, and square thread. The operation of cutting wood screws is completed in about twice or thrice passing back and forward between the cutter. It is contemplated to move the machine by man, horse, water, or any other power most convenient. From 10 to 20 of these machines may be placed on one bench and may be moved with one water wheel without any interference with each other.

A, Spindle socket and screw.
B, Slide and spring.
C, The screw for cutting.
DD, The poppet that carries the spindle socket and screw.
EE, Clams that hold four cutters.
FF, Clams, the dyes for the regulating the screws.
G, The bench.
HH, The frame that holds the pivots for the clams.
I, The lever that works by a spring to shift the spindles.
JJ, Joints that open and shut the clams.
K, The lever and handle that works the joints and clams.
L, The sliding plate under the bench, that casts the bands from one pulley to the other.
M, Handle of sliding plate.
N, Long lever that works the front and back clams.
OO, Two pullies that carry the bands.
PP, Band worked by the drum.
R, The drum.
S, The crank.
TT, The frame.
U, The treddles.

MECHANICS, Abstract of; *or, a Review of the principal Definitions and Facts in this science.*

Of Matter.

1. All substance, or matter, has the

Patent Machine for Cutting Wood Screws.

By Robert Hancocks Jn^r. & Edward M^c. Carr. Philad^a.

Plate 13.

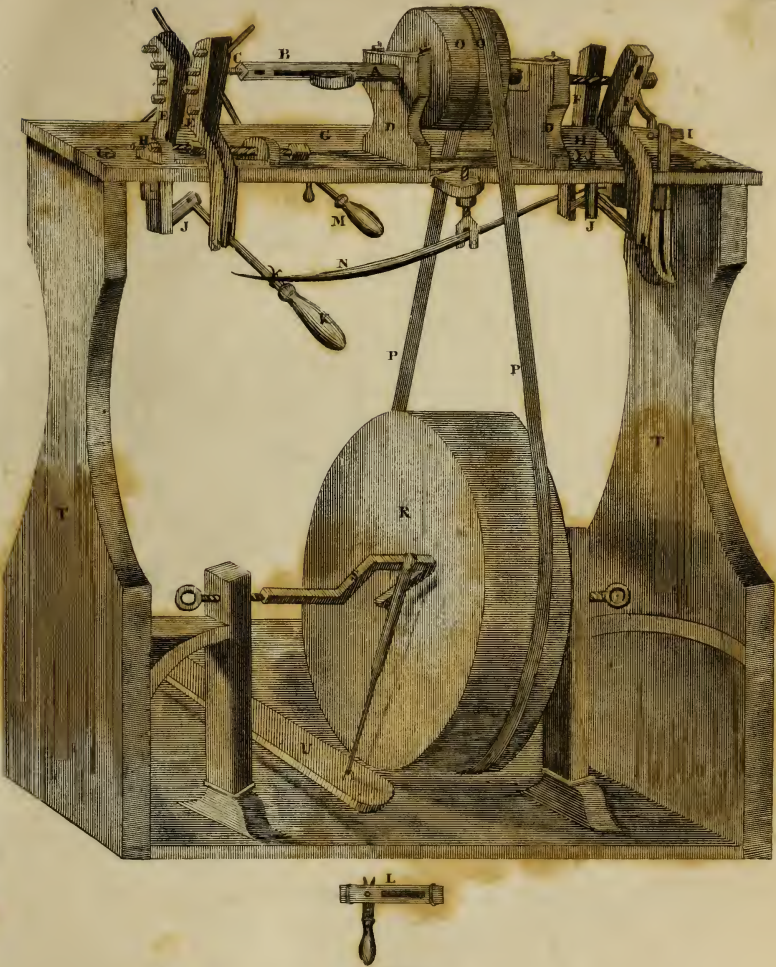


Fig. 1.

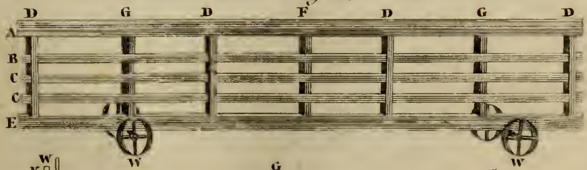
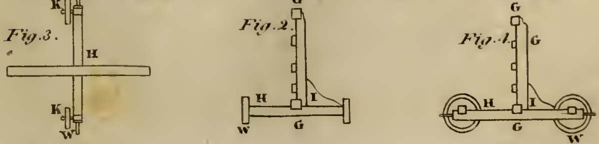


Fig. 3. *Fig. 2.* *Fig. 4.*



S. Folwell Delin. *H. Anderson sc.*

properties of solidity, or impenetrability, divisibility, mobility, and inertia.

2. All bodies appear to possess also attraction and repulsion.

3. *Solidity* is that property by which two bodies cannot occupy the same place at the same time.

4. *Divisibility* is that property by which bodies are capable of being divided into parts.

5. *Mobility* is the property of being capable of receiving motion when imparted to it.

6. *Inertia* is the tendency which bodies have to continue in the state into which they are put, whether of rest or motion.

Space.

1. Space is either absolute or relative.

2. *Absolute space* is mere extension: it has no limits or bounds, and is itself immoveable.

3. *Relative space* is that part of absolute space which is occupied by any body, and is compared with any part occupied by another body.

Motion.

1. Motion is also either *absolute* or *relative.*

2. *Absolute motion* is the actual motion that bodies have, independent of each other, and only with regard to the parts of space.

3. *Relative motion* is the degree and direction of the motion of one body, when compared with that of another.

4. *Accelerated motion* is when the velocity of the motion continually increases.

5. *Retarded motion* is when the velocity continually decreases.

6. The *velocity* of uniform motion, is estimated by the time employed in moving over a certain space; or by the space moved over in a certain time.

7. To ascertain the velocity, divide the space run over by the time.

8. To know the space run over, multiply the velocity by the time.

9. In accelerated motion, the space run over is as the *square* of the time, instead of being directly as the time, as in uniform motion.

10. A body acted upon by only one force, must always move in a straight line.

11. Bodies acted upon by two single impulses, whether equal or unequal, must also describe a straight line.

12. But if a body is acted upon by one uniform force, or single impulse, and another accelerating force, these two forces together will cause it to describe a *curve.*

13. The curve described by a body projected from the earth, and brought down again by the action of gravity, is that of a *parabola.*

14. The *momentum* of a body, is the force with which it moves, and is in proportion to the weight, or quantity of matter, multiplied into its velocity.

Attraction and Repulsion.

1. The causes of these powers are totally unknown.

2. There are various kinds of attraction—the attraction of *cohesion*, of *gravitation*, of *electricity*, *magnetism*, and *chemical attractions.*

3. The attraction of cohesion acts only at very small distances.

4. The attraction of gravitation, is that which masses of matter exert on each other at all distances.

5. Gravitation decreases from the surface of the earth, as the square of the distance.

Central Forces.

1. The central forces are the *centrifugal*, and the *centripetal* force.

2. The centrifugal force is the tendency which bodies that revolve ronnd a centre have to fly off from it in a tangent to the curve they move in—as a stone from a sling.

3. The centripetal force, is that which prevents its flying off, by impelling it towards the centre—as the attraction of gravitation.

Centre of Gravity.

1. The *centre of gravity*, is that point in which the weight of a body may be supposed to be collected.

2. A line drawn from that point perpendicular to the horizon, is called the *line of direction.*

3. When the line of direction falls within the base of any body, that body will stand; but when it falls without the base, the body will fall.

The Lever.

1. There are three kinds of levers: 1. When the fulcrum, or prop, is between the power and the weight; 2. When the prop is at one end of the lever, the power at the other, and the weight between them; 3. When the prop is at one end, the weight at the other, and the power between.

2. In all kinds of levers, the power is to the weight as the distance of the weight from the fulcrum is to that of the power from the fulcrum.

3. A *bent*, or *hammer lever*, differs only in form from a lever of the first kind.

4. A *balance* is also a lever of the first kind, with equal arms.

5. The *statera*, or *steel-yard*, is also the first kind of lever, with a moveable weight.

Wheel and Axle.

1. The power must be to the weight, in order to have an equilibrium, as the *circumference* of the wheel to the *circumference* of the axle.

2. As the diameters of circles are in proportion as their circumferences, the power is to the weight also as the *diameters*.

3. If one wheel move another of equal circumference, they will both move equally fast.

4. But if a wheel move another of different diameter, whether larger or smaller, the velocity with which they move will be inversely, as their diameters, circumferences, or number of teeth.

Pulley.

1. Pullies are of two kinds, *fixed*, and *moveable*.

2. In the *fixed* pulley, when the power and weight are equal, they balance each other, and no mechanical advantage is obtained

3. In the *moveable* pulley, the power needs only to be equal to half the weight, to balance.

Inclined Plane.

That the power and weight may balance each other, the former must be to the latter as the height of the plane to the length.

Wedge.

1. When the resistance acts perpendicularly to the sides, the power will be to the weight as half the thickness of the wedge on the back is to the length of the sides.

2. When the resistance acts parallel to the back, the power is to the resistance as the whole length of the back to that of the sides.

Screw.

1. A screw may be considered as an inclined plane.

2. It is always used with a lever; and the power is to the weight, as the distance from one thread, or spiral, to another, is to the circumference of the circle described by the power.

3. When a screw acts in a wheel, it is called an *endless screw*.

Compound Machines.

1. In all machines, simple as well as compound, what is gained in power is lost in time.

2. In any machine, the power is to the weight, when in equilibrio, in a proportion formed by the multiplication of the several proportions which the power bears to the weight, in every simple mechanical power used in the machine.

3. The power of a machine is not at all altered by varying the sizes of the wheels, provided this proportion produced at last by the multiplication of the power of each several part, remains the same.

Fly-Wheels.

1. Fly-wheels are employed to *equalize* the motion of a machine.

2. A fly cannot in any other way *add* power to the machine.

Friction.

1. Friction depends upon the roughness of bodies.

2. It increases according to the weight and velocity of moving bodies, and also according to the surface, though in a small degree.

Men and Horses, considered as first Movers.

1. A horse draws with the greatest advantage, when the line of draught is not level with his breast, but inclines upwards, making a small angle with the horizontal plane.

2. When a horse works in a circle, it should not be less than 40 feet in diameter.

3. A horse exerts most strength, when drawing horizontally.

4. In turning a winch, a man exerts his strength in different proportions at different parts of the circle. The greatest force is when he pulls the handle upwards from the height of his knee; and the least, when he thrusts from him horizontally.

5. The handles at each end of a winch should be put on at right angles to each other, and not opposite, as they often are.

Mills.

1. Water-mills are of three kinds—*undershot-mills*, *breast-mills*, and *overshot-mills*. The powers necessary to produce the same effect on each of these, must be as the numbers, 2.4, 1.75, and 1.

2. But as a fall of water cannot be always had, the *undershot*-mills are often used.

3. *Bevelled-wheels* are much used for changing the direction of motion in wheel-work.

4. Hook's *universal joint* is sometimes used for the same purpose.

5. The ends of the teeth of wheels ought never to be circular, but formed of parts of an *epicycloid*.

Pendulums.

1. All the vibrations of the same pendulum, whether great or small, are performed in equal times.

2. The longer a pendulum, the slower are its vibrations.

3. Heat expands, and consequently lengthens, pendulums; and cold contracts, and shortens them.

4. A pendulum, to vibrate seconds, must be shorter at the equator than at the poles.

5. Methods have been used for correcting the irregularity arising from expansion and contraction: one of these is the *gridiron*-pendulum.

6 *Deal* is the best substance for pendulum-rods, as it is very little affected by heat and cold.

Wheel-Carriages.

1. Wheels of carriages turn round, on account of the friction they sustain in contact with the roads.

2. Large wheels, in general, are more advantageous than small ones.

3. In four-wheeled carriages, the fore-wheels are made smaller than the hind ones, for the conveniency of turning; otherwise they would be better of the same size.

4. *Broad wheels* are better for heavy carriages—such as waggons—because they press and harden, instead of cutting up the roads, as small wheels do.

MEDALS—*The art of making impressions, or copies of Medals and Coins.* Take fish-glue or isin-glass; cut it in small pieces; immerse it in clear water, and set it on a slow fire; when gradually dissolved, let it boil slowly, stirring it with a spatula, and taking off the scum. The liquor being brought to a sufficient tenacity, take it off the fire, let it cool a little, and then pour it on the medal or coin you intend to copy, so that it may lay about the thickness of a crown-piece upon the medal. This done, set it in a moderate air, neither too hot nor too cold, and let it cool and dry; when dry, it will loosen itself, and you will find the impression exact, and the finest strokes expressed to the greatest perfection. But this method is surest on gold and copper coin, for sometimes it has been found hurtful to those of silver. You may mix this liquid with various colours, green, red, yellow, blue, &c. If you put a little parchment-size to it, it will make it harder, and answer your purpose the better. In this manner you may make a fine collection, which will answer your study as well as the real coins or medals.

Another, and more substantial method.—Take a little quantity of lead, tin, and regulus of antimony; and of copper, a larger quantity. Being melted, cast them in a mould, prepared of burned clay, in which clay you have taken the impression of both sides of your medal, or coin.—Of the method of casting, see MOULDING and CASTING.

Medals of Gum-tragacanth, to imprint.—Take six ounces of gum-tragacanth, and steep it in strong vinegar, for the space of three days; then beat and stir it well together, and add some fine plaster of Paris to make it of a sufficient substance: if you will have it of a different colour, you may mix it with such coloured powders as you like best; if blue, with fine smalt; if red, with vermilion; if green, with green verditer, or finely powdered verdigrise; if yellow, with masticot, or powdered Dutch pink; if orange-colour, with orpiment After you have thus prepared your dough to a proper consistence, you take your hollow forms, or moulds, and anoint them a little with sweet-oil, and fill them with the said dough, or paste, pressing it gently down with your fingers; and, having trimmed it round the rim with a pointed knife, set it in the sun to dry, and you will have a fair and neat impression of your mould. Of this paste you may form and make various kinds of toys.

MELTING FURNACE. A number of furnaces have been constructed for the melting of metal. For the different modes of melting metal, and of constructing melting furnaces, see IRON, COPPER, ZINC, &c.

MELASSES, or Molasses, are that gross fluid matter remaining of sugar after refining; and which no boiling will bring to a consistence more solid than that of syrup. Molasses are used with nitre in the preservation of beef, in the manufacture of tobacco, and, among poor people, as a substitute for sugar. They are also distilled with water, after undergoing fermentation, into a spirit somewhat resembling that imported from the West India islands, though possessing a more deleterious quality. See SUGAR.

MERCURY, or QUICKSILVER—Mercury is a metal of a silvery-white colour, and fluid at the usual atmospherical temperature.

Ores of Mercury.

Sp. 1. Native Mercury.

Sp. 2. Native Amalgam.

Sp. 3. Liver-coloured mercurial ore.

1 *Var.* Compact.

2 *Var.* Slaty.

Sp. 4. Bituminous mercurial ore.

Of this are the two following varieties.

1. *Var.* Branderz.
2. *Var.* Corallenerz.

Sp. 5. Cinnabar

Of this are the three following sub-species.

1. *Subsp.* Common, or dark red, C.

It occurs in mass, disseminated, investing, cellular, dendritic or crystallized. The primitive form of its crystals is the regular hexahedral prism, besides which are other varieties.

2. *Subsp.* Fibrous cinnabar.
3. *Subsp.* Hepatic Cinnabar.

Sp. 6. Horn Mercury.

Reduction of Ores.

The modes of extracting the meal from the ores of mercury are very simple. The first that we shall mention is the best and most scientific, and practised at the mines of Deux Ponts, and of Idria. The ore being brought out of the mine, is sorted by hand with considerable accuracy, rejecting those parts that appear to be destitute of metal. This is an expensive and rather tedious process, but has superseded the ancient method of separating the cinnabar by washing, on account of the prodigious loss of metal in that operation. The sorted ore being reduced to powder is carefully mingled with one-fifth more or less, according to the proportion of cinnabar contained in the ore, of quicklime which has fallen to powder by exposure to the air. This mixture is then put into iron retorts, capable of holding about 60 lbs. weight, which, when thus charged, are fixed in a long furnace, to the number of 40 or 50; a glass receiver being then attached to each retort, but not luted, a gentle fire is applied in order to drive out all the moisture; when this is effected, the juncture of the vessels is closely stopped with tempered clay, and a full red heat is applied for seven or eight hours; at the expiration of which time all the mercury will have been volatilized and condensed in the receiver. The common produce varies between six and ten ounces of metal, from 100 lbs. of the ore.

The method practised at Almaden, in Spain, differs considerably from the preceding, and is much more rude and inartificial. The pieces of pure cinnabar being first picked out from the ore, in order to be disposed of to the painters, and manufacturers of sealing wax, the rest is sorted into three parts: the first is the richest, and is in pieces of a moderate size, the second is in smaller pieces, and less abounding in metal, the third is the dust and smallest fragments of the other two, which are kneaded up with clay, and formed into bricks, that are dried carefully in the sun. The furnace used for extraction of the mercury is an oblong mass of masonry, divided horizontally into an upper and lower compartment by an iron grate, and communicating near its top with a set of aludels. The charging of the furnace commences by laying on the grate a stratum of flat rough stones, leaving intervals between each for the passage of the fire: upon this is laid a bed of ore of the second quality, then the ore of the first quality, afterwards another bed of the second kind, and at the top of all a layer of the third kind made up into bricks. A few faggots are now thrown into the lower cavity of the furnace and lighted, which, in proportion as they are consumed, are succeeded by others, and thus a gentle fire is kept up for 8 or 12 hours, according to the previous dryness of the ore. When the moisture is got rid of, which is known by the cessation of the vapour, the fire-place is again filled with faggots, and, before these are consumed, the mass of ore will be sufficiently heated to continue the combustion by means of the sulphur that it contains without any additional fuel. During the next two days, as the sulphur slowly burns away, the mercury, in the state of vapour, passes into the aludels where it is condensed; and at the end of this period, all the metal being extracted, the scoriæ are taken out of the furnace, and the aludels are emptied of their contents. Besides the mercury, a considerable quantity of a black matter like soot, is found in the aludels, which is readily separated by spreading the whole about on an inclined table: the mercury runs to the lower end, where it is collected in a channel, while the impurities remain behind.

The consumption of fuel and cost of apparatus is considerably less than in the German method, but it is probable that a portion of mercury still remains in the ore. A great loss is also sustained by throwing away the soot after separating the running mercury on the tables, for not only many globules of the metal must escape notice, but also the calomel, cinnabar, &c. which it contains, are entirely wasted.

A few of the chemical combinations of mercury, may here be noticed.

Mercury is a metal always fluid at the temperature of our climates, of a white and perfectly resplendent polished surface, so as to reflect with extreme brilliance all objects, and is without smell or taste in the metallic state. Its specific gravity is 13.56. Its expansion by heat is on the whole, very regular, till a considerable distance above the point of boiling water, and hence its use in the construction of thermometers. When exposed to

a cold of about—39 it solidifies, and when hard frozen it will bear gentle blows with a hammer; sufficient to prove its malleability; though in so doing, the friction soon heats it enough to make it reassume the liquid state. Mercury boils at about 660° and, if pure, totally evaporates without any residuum: but the vapour soon condenses upon the adjacent bodies, coating them with a white dew, which is found by the microscope to consist of myriads of minute globules. When the galvanic fluid from a powerful apparatus is passed into mercury by immersing the conducting wire into this fluid, the mercury disperses in beautiful, brilliant, luminous stars, which seems to shew that this is a combustible metal.

When mercury is agitated in a dry glass bottle, the friction between the metal and the glass produces electricity. If the bottle be imperfectly exhausted, this electricity passes into the vacuum, and produces a light, which was formerly thought to be a proof of the perfection of the vacuum in the upper part of barometer tubes; but which, in fact, does not appear in such barometers as have been cleared of air by careful boiling in the tube.

The sulphuric acid does not act on this metal, unless it be well concentrated and boiling. For this purpose mercury is poured into a glass retort, with near twice its weight of sulphuric acid. As soon as the mixture is heated, a strong effervescence takes place, sulphurous acid gas escapes, the surface of the mercury becomes white, and a white powder is produced: when the gas ceases to come over, the mercury is found to be converted into a white, opake, caustic, saline mass, at the bottom of the retort, which weighs one third more than the mercury, and is decomposed by heat. Its fixity is considerably greater than that of mercury itself. If the heat be raised, it gives out a considerable quantity of oxygen, the mercury being at the same time revived.

The white mass produced by the action of sulphuric acid upon mercury, consists partly of sulphat of mercury, and partly of oxide. Water separates the salt from the oxide, which is then of a yellow colour. Much washing is required to produce this colour, if cold water be used; but if a large quantity of hot water be poured on, the oxyde immediately assumes a bright lemon colour. In this state it is called turbith mineral. The sulphat affords by evaporation small, needly, deliquescent crystals. Sulphat of mercury may be made likewise by adding soluble sulphat to a nitric solution of mercury.

The fixed alkalis, magnesia, and lime, precipitate mercury from its solution; these precipitates are reducible in closed vessels by mere heat without addition.

The nitric acid rapidly attacks and dissolves mercury, at the same time that a large quantity of nitrous gas is disengaged; and the colour of the acid becomes green during its escape. Strong nitric acid takes up its own weight of mercury in the cold; and this solution will bear to be diluted with water. But if the solution be made with the assistance of heat, a much larger quantity is dissolved; and a precipitate will be afforded by the addition of distilled water, which is of a yellow colour if the water be hot, or white if it be cold; and greatly resembles the turbith mineral produced with sulphuric acid: it has accordingly been called nitrous turbith. If acid be added to the solution made with heat, it loses its property of being decomposed by water. This decomposition is not complete, but only deprives the acid of the redundant oxide.

All the combinations of mercury and nitric acid are very caustic, and form a deep purple or black spot upon the skin. They afford crystals, which differ according to the state of the solution. When nitric acid has taken up as much mercury as it can dissolve by heat, it usually assumes the form of a white saline mass. When the combination of nitric acid and mercury is exposed to a gradual and long continued low heat, it gives out a portion of nitric acid, and becomes converted into a bright red oxide, still retaining a small portion of acid. This is known by the name of red precipitate, and is much used as an escharotic.

When red precipitate is strongly heated, a large quantity of oxygen is disengaged, together with some nitrogen, and the mercury is sublimed in the metallic form.

Nitrat of mercury is more soluble in hot than cold water, and affords crystals by cooling. It is decomposed by the affusion of a large quantity of water, unless the acid be in excess.

When mercury is dissolved in nitric acid by means of heat, nitrous gas is emitted at first; and afterward it ceases, though the solution still proceeds. If the solution be stopped in the first part of the process, pure alkalies precipitate the yellow oxyd; but if the solution be continued after the escape of the elastic fluid has ceased, the precipitate obtained by the same means is black.

Barytes, magnesia, and lime, precipi-

tate the nitric solutions of mercury; and these precipitates, as well as all the other oxides of this metal, are reducible by heat alone without addition.

The precipitates of mercury from acids, by means of alkalies, possess the property of exploding when exposed to a gradual heat in an iron spoon, after having been previously triturated with one-sixth of their weight of flowers of sulphur The residue consists of a violet-coloured powder, which is converted by sublimation into cinnabar. It seems therefore, as if the sulphur combined suddenly with the mercury, and expelled oxygen in the elastic state.

Another fulminating preparation of mercury was discovered by Mr. Howard. An hundred grains of mercury are to be dissolved by heat in an ounce and half, by measure, of nitric acid. This solution being poured cold into two ounces by measure of alcohol in a glass vessel, heat is to be applied, till effervescence is excited. A white vapour undulates on the surface, and a powder is gradually precipitated, which is immediately to be collected on a filtre, well washed, and cautiously dried with a very moderate heat. This powder detonates loudly by gentle heat, or slight friction. Mr. Accum having made four ounces of this powder, and left it to dry on a chalk stone, where it was forgotten for three months, found it converted into a brilliant black powder; and on collecting it into a heap, observed a globule of running mercury. On putting it into a bottle, and shaking it, heat was evolved, and the whole of the metal reduced. Brugnatelli has made this preparation without heat, by pouring an ounce of alcohol on two drachms of yellow oxyde of mercury, and adding at twice, ten drachms of strong fuming nitrous acid. The alcohol is converted into ether, which escapes in very copious vapours. All the other oxides of mercury were equally convertible into fulminating mercury by the same means. In either way the ether might be saved by a proper apparatus.

The acetous and most other acids combine with the oxyde of mercury, and precipitate it from its solution in the nitric acid.

The muriatic acid seizes the mercury dissolved in the nitric acid, and forms a compound which falls to the bottom. This consists of a very caustic salt, which is called corrosive sublimate, and is produced when the nitric solution contains highly oxided mercury; but when that solution is saturated with mercury in a less oxided state, the compound which falls down by the addition of muriatic acid is called white precipitate, and differs little from the preparation which, when made in the dry way, is called calomel, or mercurius dulcis.

The muriatic acid does not act perceptibly upon mercury in the metallic state; but the oxigenized muriatic acid readily dissolves it, and forms the same combination as arises from the direct union of muriatic acid with oxyde of mercury; that is to say, corrosive sublimate. This is generally made by mixing sulphat of mercury with muriat of soda, and exposing them to heat gradually raised; when the muriat of mercury sublimes. This muriat being mixed by trituration with three-fourths its weight of mercury, and sublimed again; the sublimate powdered, and re-sublimed three or four times; and the product well washed; we have the mild muriat, or calomel. The corrosive muriat contains, according to Mr. Chenevix, 69·7 mercury, 12·3 oxygen, and 18 muriatic acid: the mild, 79 mercury, 9·5 oxygen, and 11·5 acid.

The causticity of metallic salts depends chiefly on the disposition of the oxide to resume the metallic state, in doing which it burns the substance to which it may be applied by the oxigen it evolves. It is accordingly found, that corrosive sublimate possesses this property in a very eminent degree; it is therefore one of the most active mineral poisons. This salt is soluble in water, though sparingly, and also in alcohol. It is precipitated of an orange colour by fixed alkalis. The absorbent earths likewise throw down its oxide. Volatile alkali affords a white precipitate, which soon afterward assumes a slate colour.

Corrosive sublimate becomes much more soluble in water by the addition of sal ammoniac, with which it forms a triple compound, called sal alembroth by the alchemists, which crystallizes by cooling. The addition of a fixed alkali throws down a white oxide of mercury, called white calx of quicksilver in the London Dispensatory.

When one part of native sulphuret of antimony is triturated or accurately mixed with two parts of corrosive sublimate, and exposed to distillation, the oxigenized muriatic acid combines with the antimony, and rises in the form of the compound called butter of antimony; while the sulphur combines with the mercury, and forms cinnabar. If antimony be used instead of the sulphuret, the residue which rises last consists of running mercury, instead of cinnabar.

Mercury combines very readily with sulphur. By trituration in a mortar the mercury disappears, and forms a black

sulphuret, which was formerly called ethiops mineral, or mercurial ethiops. The combination is more speedily made by mixing fluid mercury with melted sulphur. In this way three parts of flowers of sulphur unite with one of mercury. If the sulphur be set on fire, the greater part burns, and the remainder is of a violet colour when pulverized. This consists of a more intimate combination of mercury and sulphur. It rises in a heat nearly approaching to redness; and the sublimate, which is called cinnabar, contains about one fifth part sulphur, and the rest mercury. Mr. Accum has made cinnabar in the humid way, by mixing equal parts of concentrated solutions of oxigenized muriat of mercury and fresh prepared fuming hydrosulphuret of ammonia. A brownish muddy precipitate is produced, which, being left undisturbed, turns yellow in three or four days, then orange, and at last the beautiful red of the best vermilion. Proust says, that mercury, poured into flasks containing sulphuret of potash or of ammonia, unites with the sulphur, and falls down in a black powder, which in the space of a few days becomes red. According to Seguin, cinnabar is composed uniformly of $86\frac{2}{3}$ mercury, and $13\frac{1}{3}$ sulphur; while in the black sulphuret the proportions are very variable. In the native cinnabar of Japan, however, Klaproth found 14.75 per cent of sulphur, and in that of Carniola 14.25. The pigment called vermilion consists of artificial cinnabar reduced to a powder.

If phosphorus be added to a nitric solution of mercury, the metal will be precipitated on it in globules, which will be converted into a black phosphuret by heating to ebullition.

Mercury unites by trituration with dense oils and mucilages, with which it forms black or deep blue compounds. A small part of the mercury in these seems to be in combination, and the rest in a state of extreme division. Rancid oils combine with mercury better than such as are fresh.

Mercury, being habitually fluid, very readily combines with most of the metals, to which it communicates more or less of its fusibility. When these metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called amalgams.

It very readily combines with gold, silver, lead, tin, bismuth, and zinc; more difficultly with copper, arsenic. and antimony; and scarcely at all with platina or iron: it does not unite with nickel, manganese, or cobalt: and its action on tungsten and molybdena is not known. Looking-glasses are covered on the back surface with an amalgam of tin. See Silvering.

The uses of mercury have already been mentioned in the present article, and elsewhere. The amalgamation of the noble metals, water-gilding, the making of vermilion, the silvering of looking-glasses, the making of barometers and thermometers, and the preparation of several powerful medicines, are the principal uses to which this metal is applied.

From the importance of the medicinal uses of this metal, and of having it perfectly pure for many other purposes, we shall subjoin the following methods of detecting adulterations, either of the metal itself, or its principal preparations, from Mr. Henry.

Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses of dissolving completely some of the baser metals. This union is so strong, that they even rise along with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing, and becoming covered with a coat of oxide, on long exposure to the air; by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these, if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxidize that metal. Pour off the water, and digest the mercury with a little acetous acid. This will dissolve the oxide of lead, which will be indicated by a blackish precipitate with sulphuretted water. Or to this acetous solution add a little sulphat of soda, which will precipitate a sulphat of lead, containing, when dry, 72 per cent. of metal. If only a very minute quantity of lead be present in a large quantity of mercury, it may be detected by solution in nitric acid, and the addition of sulphuretted water. A dark brown precipitate will ensue, and will subside if allowed to stand a few days. One part of lead may thus be separated from 15263 parts of mercury. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear if this metal be present. Tin is manifested, in like manner, by a weak solution of nitromuriat of gold, which throws down a purple sediment; and zinc by exposing the metal to heat.

The *red oxide* is rarely found adulterated, as it would be difficult to find a sub-

stance well suited to this purpose. If well prepared, it may be totally volatilized by heat.

The *red oxide* of mercury by *nitric acid* is very liable to adulteration with red lead. This fraud may be discovered by digesting it in acetic acid, and adding to the solution sulphuretted water, or sulphuret of ammonia, which produces, with the compounds of lead, a dirty dark-coloured precipitate. It should also be totally volatilized by heat.

White oxide of mercury. White lead is the most probable adulteration of this substance, and chalk may also be occasionally mixed with it. The oxide of lead may be discovered as in the last article; and chalk, by adding to the dilute solution a little oxalic acid.

Red sulphuret of mercury is frequently adulterated with red lead; which may be detected by the foregoing rules. Chalk and dragon's blood are also sometimes mixed with it. The chalk is discovered by an effervescence on adding acetic acid, and by pouring oxalic acid into the acetous solution. Dragon's blood will be left unvolatilized when the sulphuret is exposed to heat, and may be detected by its giving a colour to alcohol, when the cinnabar is digested with it.

Black sulphuret of mercury. The mercury and sulphur, in this preparation, should be so intimately combined, that no globules of the metal can be discovered by a magnifier; and that, when rubbed on gold, no white stain may be communicated. The admixture of ivory black may be detected by its not being wholly volatilized by heat.

Yellow oxide, or sub-sulphat of mercury, should be wholly evaporable, and, when digested with distilled water, the water ought not to take up any sulphuric acid, which will be discovered by muriat of barytes.

Corrosive muriat of mercury. If there be any reason to suspect arsenic in this salt, the fraud may be discovered as follows: Dissolve a small quantity of the sublimate in distilled water; add a solution of carbonat of ammonia till the precipitation ceases, and filter the solution. If, on the addition of a few drops of ammoniated copper to this solution, a precipitate of a yellowish green colour be produced, the sublimate contains arsenic.

Sub-muriat of mercury, or calomel, should be completely saturated with mercury. This may be ascertained by boiling, for a few minutes, one part of calomel with a thirty-second part of muriat of ammonia in ten parts of distilled water. When carbonat of potash is added to the filtered solution, no precipitation will ensue, if the calomel be pure. This preparation, when rubbed in an earthen mortar with pure ammonia, should become intensely black, and should exhibit nothing of an orange hue.

METALS.—Metallic substances are very easily distinguishable from all other bodies in nature, by their very great weight, and that opake shining appearance, which is called the metallic splendour or brilliancy. Very few substances have half the specific gravity of the lightest among the metals. They are all fusible, though at very different temperatures; and if the fusion be made in close vessels, they fix again by cold, without having suffered any change but that of external figure, which must be produced in all bodies which have been either liquefied or volatilized; namely, they assume the form of the vessel which contains them. Some of them may be extended considerably by the hammer, without breaking them. This property is called malleability; and the metallic bodies which possess it are called entire metals, or metals, in contradistinction to such as are more brittle, and are called semimetals. Metallic substances are also called perfect and imperfect. The perfect are such as undrego no lasting change of their properties by any heat we can apply to them, at least in common furnaces. The imperfect metals, when exposed to a strong heat, with access of oxigen, are changed, by a process similar to burning, and in some of them with an actual flame, into a brittle dull substance, called an oxide, which is heavier than the metal it came from, though its specific gravity is not so great. Some are even converted into acids. If the oxide of a metal be exposed to strong heat in a closed vessel, with some inflammable matter, it recovers its metallic state. This is called reduction, or reviving of the metal.

A more recent arrangement of metals, and perhaps the best, is that of Dr. Thomson, who divides them into 4 classes. 1. *Malleable metals.* Platina, gold, silver, nickel, mercury, palladium, rhodium, iridium, osmium, copper, iron, tin, lead, and zinc. 2. *Brittle and easily fused.* Bismuth, antimony, tellurium, and arsenic. 3. *Brittle and difficult of fusion.* Cobalt, manganese, chrome, molybdena, uranium, tungsten, and titanium. 4. *Refractory*, or such as have never yet been reduced. Columbium, tantalium, and cerium.

Metals, like other fusible bodies, have each a fixed temperature, or freezing point, at which they become solid. They assume a crystallized figure in cooling,

which is different in each, and may be seen by fusing them in melting-pots with a hole in the bottom stopped with a stopper; or better, in many cases, by a dish or flat mould, and tilting it; for, in this case, if the surface be suffered to congeal, and the fluid metal beneath be suffered to run out through the hole, the under surface of the remaining metal will be curiously crystallized. The specific gravity of metallic substances is very considerably affected by the gradual or hasty cooling, or transition from the fluid to the solid state. Hammering renders them harder and more elastic; but this effect is destroyed by ignition.

The affinities of metals to each other are various. Some will not unite at all; others mix very readily, and even combine together. On this property is founded the art of soldering; which consists in joining two pieces of metal together by heating them, with a thin piece or plate of a more fusible metal interposed between them. Thus tin is a solder for lead; brass, gold, or silver, are solders for iron, &c.

Mountainous districts, where the surface of the globe has been thrown up or disturbed, in remote ages, by earthquakes, volcanoes, or other great convulsions of nature, are the most abundant in metallic bodies. In digging into the bowels of the earth, the various metals are mostly found disposed in strata or beds, which in plains lie level, but in mountains are inclined; whence it happens, that in mountainous countries some strata are often exposed to the day, which would else have been too deeply lodged to be come at by human art. It is in the stratified mountains that metals are usually found, mostly in a state of combination either with sulphur or arsenic, or in the state of an oxide. They are also found, though less frequently, in the metallic or native state.

The combinations, or earthy bodies which contain metals in sufficient quantity to be worth extracting, are called ores. Iron ore sometimes forms entire mountains; but in general the metallic part of a mountain is very inconsiderable in proportion to the whole. The ores run either parallel to the stony strata, though far from having the same regularity of thickness, or they cross the strata in all directions. These metallic strata are called veins. The cavity formed by art in the earth, for the extraction of metals or any other mineral bodies, is called a mine. The stone, wherein a metallic ore is usually bedded, is called its matrix. These are not peculiarly appropriated to any metal, though some stones more frequently accompany metals than others.

The general operations by which metals are obtained from ores, are—1. The minerals are selected; and such only are taken as from experience are known, by the external figure or appearnce, to contain metal. 2. They are reduced to powder; and the lighter parts washed away, by means of water, in a shallow trough. 3. The volatile parts are dissipated by the operation called roasting. 4. The ores are smelted by throwing them into the midst of the fuel of a furnace, with earthy substances, which are disposed to run into glass. In this operation, the glassy matter, called scoria, in some measure produces the effect of rendering the lower part of the furnace a closed vessel; and the fuel revives the metal, which in the ore is usually of the nature of oxide. The revived metal being much denser than the scoria, falls to the bottom, and is suffered to run out by proper openings. These are the general operations, but they are not all necessary in all cases; and the particular practice with the several ores of each metal must vary according to the properties of the metal itself, and the different substances it is united with.

The extraction of metals from ores, in the small way, which is necessary to be made, in order to ascertain whether the specimens be worth working, is called assaying or essaying. In these small trials, the fusibility of the pounded ore is increased by an addition of black flux, which is an impure alkali, formed by mixing two parts of tartar with one of nitre, and setting them on fire. Metallic ores may be very accurately assayed by solution and precipitation in the humid way. See the several Metals, also Assay.

Most metals will uniformly mix with each other; and the specific gravity of the compound is seldom such, as would have been deduced from the supposition of a mere mixture, or simple apposition of parts. Their fusibility is likewise greatly changed by mixture, and according to no certain rule yet discovered.

Mixtures of metals are frequently called alloys. But the word alloy, or allay, is mostly used to denote a portion of metal which is added to the precious metals, gold or silver.

Metals are mostly soluble in acids, with which they form salts. When a metal is added to an acid, the general effect produced is the same as would have arisen from the addition of any other combustible substance to the acid. If an alkali or earth be added to a metallic solution, the metal falls to the bottom in the

form of an oxide. But if a metal, which has a stronger affinity with the acid than the metal already dissolved has, be added to such a solution, the former metal will fall to the bottom in its metallic state, and the latter will be dissolved without causing any of the escape of elastic fluid, and other appearances, which would have taken place if it had been applied to the mere acid; notwithstanding which, the latter metal, if precipitated by an incombustible substance, such as an alkali or earth, will be in the state of an oxide. Phosphorus likewise precipitates them in the metallic state.

It is evident, from these facts, that the action of acids upon metals is similar to that of heat with access of oxigen; and of course may be accounted for in the same manner as combustion itself.

Metals are precipitated by each other in the same order, or nearly so, in all acids. Hence it is inferred, that this effect is produced by the reaction of some common principle, and this is the oxigen of the acids.

Acids dissolve metals only in their oxided state; and there is a certain limit near which the solution is best performed. If an acid be of such a nature as to be incapable of oxiding a metal, it will not dissolve it, though the same acid would dissolve the oxide, if presented to it; and if the oxidation be carried too far, the oxide will likewise be insoluble. To explain this it may be observed, that the simple metal attracts as much oxigen from the acid as is sufficient to convert itself into an oxide, but not enough to saturate it with that principle; it is therefore suspended, in consequence of its remaining weak attraction for the oxigen of the acid. But if the oxidation be complete, that is to say, if the affinity of the metal for oxigen be perfectly satisfied, the remaining attraction of the metal for oxigen will cease, and it will be insoluble.

The direct action of alkaline salts upon metals is not considerable: but several of the oxides are dissolved by them; and from these solutions the metal may be precipitated in its metallic state, by adding another metal more soluble in the alkali. Sulphur combines with most of them readily in the way of fusion; and the combination of sulphur with an alkali is a powerful solvent of all metals except zinc. Nitre heated with metals acts in the same manner as it does with other inflammable bodies: it deflagrates, and the metals become oxided. The perfect metals resist the action of nitre.

METALLIC PAINTS. See Colour Making.

METALLIC SPECULUM. See Speculum.

METALLURGY.—The characters, from which mineralogists pretend to assert the existence of an ore in the bowels of the earth, are all equivocal and suspicious. The savage aspect of a mountain, the nature of the plants which grow upon it, the exhalations which arise from the earth, all afford characters too doubtful, for a reasonable man to risk his fortune upon such indications alone.—The dipping wand, or divining rod, is the fruit of superstition and ignorance; and the ridicule, which has been successively thrown upon this class of impostors, has diminished their number; at the same time that the numerous dupes of this class of men have rendered their successors more prudent. It is nevertheless used in Cornwall, in Great Britain, to this day.

The nature of the stones which compose a mountain is capable of furnishing some indications. We know, for example, that ores are seldom found in granite and the other primitive mountains; we know likewise, that mountains of modern formation contain them very rarely; and we find them only in secondary mountains, in which the schistus and ancient calcareous stone are void of all impressions of shells.

The presence of ponderous spar, forming a stratum or vein at the surface of the earth, has been considered by many mineralogists as a very good indication. Chaptal shows very good reason for believing, that this stone is the same which Becher has spoken of in his works, under the name of Vitrifiable Earth, which he considered as a principle of metals; and that it has been very improperly taken for quartz by his readers.

When we possess indications of the existence of an ore in any place, we may use the borer, to confirm or destroy these suspicions, at a small expense.

It frequently happens, that the veins are naked or uncovered: the mixture of stones and metals forms a kind of cement, which resists the destructive action of time longer than the rest of the mountain; and as these parts of rocks, connected by a metallic cement, present a stronger resistance to the action of waters, which incessantly corrode and diminish mountains, and carry away their parts into the sea, we frequently observe the veins projecting on the sides of mountains incrusted with some slight metallic impression, altered by the lapse of time.

The nature of an ore is judged from inspection. A slight acquaintance with this subject is sufficient to enable the ob-

serve to form an immediate judgment of the nature of an ore. The blowpipe is an instrument, by the assistance of which we may in a short time become acquainted likewise with the species of the ore. This knowledge forms the docimastic art, or docimasia. In order to make the assay of an ore, in general, for all ores do not require the same process, small pieces of the mineral are examined. These are cleared from foreign and stony substances as much as possible. The pure mineral is then pounded, and a certain quantity weighed, which is torrified in a vessel larger and less deep than a common crucible. By this means the sulphur, or the arsenic in combination with the metal, is dissipated; and by the loss of weight resulting from the calcination, a judgment is formed of the proportion of foreign volatile matter it contained.

The first operation shows the proportion and quantity of sulphur and arsenic, which may be mixed with the metal. The sulphureous smell may easily be distinguished from the smell of garlic, which characterizes arsenic. These foreign substances mixed with the metal are called mineralizers.

In order to obtain an accurate judgment of the weight of the mineralizer, the augmentation in weight, which the metal has undergone in passing from its metallic state to that of oxide, must be added to the loss occasioned by the calcination.

Two hundred grains of this roasted ore are then to be taken, and mixed with fluxes capable of fusing and reducing it. In this operation a crucible is made use of; and a sufficient degree of heat being applied, the metal is precipitated to the bottom of the crucible in a button, the weight of which indicates the quantity of metal contained in the ore.

These fluxes must be varied according to the nature of the ores under examination. It is necessary that they should all contain carbon, to disengage the oxigen with which these metals are combined. But the nature of the flux must be varied according to the fusibility of the metal. The following will answer all these purposes:

1. The fusible material called black flux is made with two parts of tartar, and one part of nitre, melted together. The carbonaceous and alkaline residue is used to reduce the ores of lead, copper, antimony, &c.

2. Two hundred grains of calcined borax, one hundred grains of nitre, twenty grains of slaked lime, and one hundred grains of the ore intended to be assayed, form the flux of Scopoli, which Chaptal found advantageous in the assay of iron ores.

3. The vitreous flux of Guyton-Morveau, made with eight parts of pounded glass, one of borax, and half a part of powder of charcoal, may be employed for the same purpose.

4. Arsenic and nitre, in equal parts, form likewise a very active flux.

The neutral combination of oxide of arsenic and potash has been used with success to fuse platina.

As soon as the existence of a mine and its nature and riches are ascertained, it is in the next place necessary to be assured of a sufficient abundance and continuity of water, to answer the purposes of the works. It is likewise necessary, to be assured of possessing a sufficient quantity of wood or coal, and more especially a good director must be procured: for a poor mine well managed is preferable to a rich one ill conducted.

Those preliminary circumstances being accomplished, the most simple and least expensive processes must be employed in extracting the mineral from the bowels of the earth. For this purpose, shafts or galleries must be dug, according to the position of the vein, and the nature of its situation.

When it is practicable to arrive at the side of the vein, and at a certain depth, by a horizontal gallery, the works become more simple and œconomical; the same opening serving to draw off the waters, and extract the ore. Galleries are then to be carried on to the right and left; and shafts sunk, which communicate with the open air, as likewise others carried down into the vein. Galleries are likewise constructed, one above the other, and the communication of the works kept up by ladders. When the soil is friable, and defective in solidity, care must be taken to support it with timbers of sufficient strength to prevent its falling in.

Pickaxes, wedges, and levers are used to detach the ore, when the rock is soft; but it is most commonly necessary to employ gunpowder.

Want of air, and the abundance of water, are almost always noxious, and derange mine-works. The water is carried off by steam-engines, wind-mill pumps, and other suitable apparatus.

Currents of air are produced by establishing communications with the galleries, by horizontal apertures. Furnaces erected on the side of a shaft, to which a long tube is adapted at one end, communicating with the ash-hole, and at the other

plunging into the shaft to draw up the air, or ventilators placed in the same situation, answer a similar purpose. The foul air is destroyed by exposing to it a caustic lixivium: sprinkling quicklime about the mine likewise produces the same effect.

A prudent company ought to extract the largest possible quantity of ore, before they determine upon constructing the necessary works for the subsequent processes. We cannot see into the bowels of the earth. Appearances are often deceitful; and we have seen companies either ruined or discouraged, because they had employed immense sums to construct the necessary furnaces to work an ore, the existence of which was doubtful. When the proceedings, in an undertaking of this kind, are carried on with proper precaution, and no more expense is entered into than what the ore extracted, and of a known value, is capable of defraying, the probable losses are very slight, even in the poorest mine.

The works ought to be varied according to the nature and state of the mineral. It is found in three states:—1. In the form of a native metal: in this case, nothing more is necessary than to extract it out of the mine, to clear it of the extraneous substances, and to fuse it. 2. In the form of oxide: and in this state it is sufficient, if it be sorted and fused. 3. Combined with sulphur or arsenic, in which case it must be made to undergo some other operations.

Although, in this last case, the works, subsequent to the extraction, vary according to the nature of the ore, there are nevertheless certain general operations, to which every kind of ore is subjected.

The first business must be to clear the metal of the stony matter or matrix. For this purpose, when the ore is extracted, children are employed, who examine it, and separate the pure ore, or rich mineral, from that which is mixed with the gangue. As in this second quality the stone is mixed with the ore, the whole is pulverized by means of a stamping mill, consisting of pestles of wood, shod with iron, and armed with cocks, which are raised by levers proceeding from the axis of a wheel which constantly turns. The mineral is by this means crushed and pulverized; and a stream of water, which is made to pass over it, carries away both the metallic and stony particles; the former being deposited in the first vessels through which the water is made to circulate, while the latter, or stony part, is carried to a greater distance, on account of its comparative lightness.

This pulverized ore is called sclich; and in order to separate all the earthy parts, it is washed upon tables slightly inclined, over which a constant stream of water is made to flow. The sclich is agitated with brooms; the water carries away all the fragments of stone, and leaves the pure ore upon the table.

The roasting of the mineral succeeds the washing. In this operation, the mineralizer is carried off. Fire is always the agent made use of. Sometimes the pounded mineral is disposed in piles upon heaps of fuel, which, being set on fire, heat the ore strongly, and drive off the mineralizer. This calcination possesses the double advantage of disposing the metal for fusion, as well as clearing it of the mineralizing substance When the ore is more friable, it is spread out in a reverberatory furnace; and the flame which reverberates upon it deprives it of its mineralizer, at the same time that it partly fuses it.

Mr Exchaquet has proposed to destroy the sulphur by nitre in assays. This process is excellent for copper ores: the quantity of nitre varies according to the quantity of sulphur; but there is no danger of adding too much. In this operation the mixture is thrown into an ignited crucible, and kept at a moderate heat for some minutes.

The fusion is effected in furnaces, excited by a current of air, kept up by means of large bellows, or a machine called a trompe

METALLIC LEAVES or Foils.—It is customary to place thin foils, or leaves of metal under precious stones, to make them look transparent, and to give them an agreeable colour, either deep or pale: thus, if a stone is to be of a pale colour, put a foil of that colour under it; again, if you would have it deep, lay a dark one under it: besides, as the transparency of gems discovers the bottom of the ring they are set in, artificers have found out those means to give the stone an additional beauty.

These foils are made either of copper or gold, or gold and silver together: we shall first mention those made of copper only, which are generally known by the name of Nuremburg or German foils.

Procure the thinnest copper plates, the thinner they are the less trouble they will give in reducing them to a finer substance: beat these plates gently upon a well polished anvil, with a polished hammer, as thin as possible; but before you go about this work, take two iron plates, about six inches long, and as wide, but no thicker than writing-paper; bend them so as to fit one on the other; between these neal

the copper you design to hammer for the foils, to prevent ashes, or other impurities getting to it; then, taking them out, shake the ashes from them, and hammer the copper until cool. Then take your foils to the anvil, and beat them until they become very thin, and whilst you beat one number, put in another between the irons to neal; this you may repeat eight times, until they are as thin as the work requires. You must have a pipkin with water at hand, in which put tartar and salt, of each an equal quantity; boil, and put the foils in, and stir them continually, until, by boiling, they become white: then take them from the fire; wash them in clean water; dry them with a clean fine rag, and give them another hammering on the anvil, until they are fit for your purpose.

N. B. Care must be taken in the management of this work, not to give the foils too much heat, to prevent their melting; neither must they be too long boiled, for fear of attracting too much salt.

How to polish and colour foils.—Take a plate of the best copper, one foot long, and about five or six inches wide, polished to the greatest perfection: bend this to a convex shape, lengthwise, and fix it to a bench, or table: then take some whiting, and having laid some on the roll, and wetted the copper all over, lay your foils upon it, and with a polish-stone and the whiting, polish your foils, until they are as bright as a looking-glass; then dry them between a fine rag, and lay them up secure from the dust. We shall now show how these foils are coloured.

Lay the foils upon a pair of tongs; hold them over the hole that is at the top of the furnace, which is to be used so that the fumes of the coals may come in contact and move them about till they are of a brownish violet colour. If the colour is to be of a sky blue, then put the foils upon the tongs as before; and whilst you, with one hand, are holding the foils over the holes, fling, with the other, some light fuel upon the live coals in the funnel, and with a red-hot poker press it down, to drive the smoke through the holes of the oven, which gives them a fine sky colour: but you must have your eyes very quick upon them, and, as soon as you see that they have attracted the colour you design, take them away from the oven, to prevent their changing to some other colour; if you would have your foils of a sapphire blue, then first silver them over; which is done in this manner:

Take a little silver and dissolve it in aqua-fortis; when dissolved, put spring water to it; fling thin bits of copper into it, and the water will look troubled, and the silver precipitate and hang to the copper; pour off that, wash the silver with water, and let it dry in the sun; when dry, grind it on a porphyry: then take one ounce of tartar, and as much of common salt; mix and grind them all together, till they are well mixed; fling this powder upon the thin foils, and rub them with your finger backwards and forwards, and it will silver them; then lay them upon the polisher, pour water over them, and some of the powder, and rub it with your thumb till they are as white as you would have them: polish them, and holding them over the smoke, they will take a fine dark blue.

METALLIC POWDER (NUREMBERG.) Mix together clean filings of copper, brass, iron, steel, and other metals. Put each of them separately into an iron vessel, and heat them till they change colour. The degree of heat can only be regulated by trial. Take these to a good flatting-mill, furnished with a funnel at top, and pass these filings through it, and you will procure a most beautiful sparkling powder of all sorts of lively colours.

METEOROLOGY.—As the science of meteorology is important to mankind, we have thought it better to give the following short treatise, for which we are indebted to Nicholson.

The state and condition of the great fluid mass, in which we breathe, and the changes which take place therein, are objects of no small importance to the chemical philosopher. Among the variety of experiments on permanently elastic fluids, it is found, that most of them are capable of uniformly mixing together, when their nature is such as not to act perceptibly upon each other. But in the extensive mass of the atmosphere, it seems likely, that considerable separations of its component parts take place, in consequence of their different specific gravities. This supposition is countenanced by several optical phænomena, such as the double appearance of head lands. In this way some writers account for the appearance of the aurora borealis, shooting stars, and other similar appearances, which they suppose to consist of hydrogen gas, occupying the upper region of the atmosphere, and fired by electricity. It is a remarkable circumstance, that most of these fiery appearances happen at an elevation, which is geometrically determined to be almost twice as great as that which astronomical writers, by deductions founded on the refraction of the light of the heavenly bodies, and the law of dilatation of air near the surface of the earth, have assigned as

the sensible limit of the atmosphere. Hence it should follow, that the elasticity of the upper parts exceeds that of the lower; which affords no inconsiderable presumption, that this upper part is chiefly composed of such air as we know to be the most elastic, namely, hydrogen. The composition of water, out of the two ingredients, oxigen and hydrogen, has also afforded ground for meteorological induction. It has been concluded, that water is not only condensed and precipitated by the agency of electricity, in thunder storms, but that it is likewise composed out of its elements by the combustion of these two airs, in every case where atmospherical corruscation is exhibited.

The phænomena of winds, though chiefly depending on the hydrostatical change in the density of the air by alteration of temperature, well deserve the attention of the chemist. The effect of furnaces, the clearing of laboratories, burial vaults, houses of office, mines, and other excavations, from noxious effluvia, are all governed by general laws of the same nature, as those which cause the currents of air around us. Even the sudden and frequently impetuous current of air, which accompanies a fall of rain, or squall, though it is merely produced by the mechanical action of the falling drops of water, has afforded ground for useful meditation. There is no doubt, but we are indebted to considerations on this natural appearance for the cheap and useful blowing-machine, which the French call a trompe.

It may seem at first sight, as if observations on the standing of the barometer and thermometer were of no very immediate use to the practical chemist. But if it be considered, that the effect of an air furnace depends on the difference of the density of the air in the chimney, and that which enters the ash-hole; and that the mere difference indicated by the barometer amounts to one fifteenth part, in its extremes, of the whole quantity of the external air, in a given place; not to mention the effect pointed out by the thermometer; it will not appear strange, that these causes should greatly influence the results in metallurgical operations, and be very perceptible in the burning of our culinary fires. The philosophical chemist is no less interested in the state of the air, as shown by these instruments. For it cannot but be of great consequence to his deductions, to know the external pressure, which is constantly acting upon the elastic fluids he may either weigh or measure. If this and the temperature be not carefully attended to, he will scarcely find any two results, made at distant times, agree.

The presence of moisture, or rather its disposition to be absorbed, or given out, as shown by the hygrometer, must be of considerable importance. It affects the elasticity of every kind of air, and there is no doubt but combustion and its products will vary accordingly as it is maintained by an air, which is moister or more dry. It is probable, that the quantities of finery cinder afforded by iron may vary from this cause.

The effects of solution and precipitation, analagous to what happens in denser fluids, have been, perhaps too fancifully, delineated among the atmospheric changes. But there is every reason to think, that, as our knowledge of the great system of nature shall improve, the play of the chemical affinities will show itself more evidently in the atmosphere.

Within these few years the attention of chemists has been particularly called to a very remarkable phænomenon in this department of science. Reports of stones falling from the atmosphere had been generally discredited, from the improbability of the fact. But the progress lately made in science has established so many facts contrary to long received opinions, and so far extended the limits of possibility, that men are become much more cautious of peremptorily refusing to credit a thing, merely on account of its seeming improbable; and are inclined to investigate, before they deny. Thus an inquiry has been instituted, and it appears, that such occurrences have been recorded from time to time from a remote period, that they have happened in various quarters of the globe, that the testimony is corroborated by circumstances, and that in many recent instances it appears incontrovertible.

It is remarkable, that all the stones, at whatever period, or in whatever part of the world, they may have fallen, have appeared, as far as they have been examined, to consist of the same substances; and to have nothing similar to them, not only among the minerals in the neighbourhood of the places where they were found, but among all that have hitherto been discovered in our earth, as far as men have been able to penetrate. For the chemical analysis of a considerable number of specimens, we are particularly indebted to Mr. Howard, as well as to Klaproth and Vauquelin, and a precise mineralogical description of them has been given by the Count de Bournon and others.

They are all covered with a thin crust

of a deep black colour, they are without gloss, and their surface is roughened with small asperities. Internally they are grayish, and of a granulated texture, more or less fine. Four different substances are interspersed among their texture, easily distinguished by a lens. The most abundant is from the size of a pin's head to that of a pea, opake, with a little lustre like that of enamel, of a gray colour, sometimes inclining to brown, and hard enough to give faint sparks with steel. Another is a martial pyrites, of a reddish yellow colour, black when powdered, not very firm in its texture, and not attractable by the magnet. A third consists of small particles of iron in a perfectly metallic state, which give to the mass the quality of being attracted by the magnet, though in some specimens they do not exceed two per cent. of the whole weight, while in others they extend to a fourth. These are connected together by a fourth of an earthy consistence in most, so that they may be broken to pieces by the fingers with more or less difficulty. The black crust is hard enough to emit sparks with steel, but may be broken by a stroke with a hammer, and appears to possess the properties of the very attractable black oxide of iron. Their specific gravity varies from 3.352 to 4.281.

The crust appears to contain nickel united with iron, but Mr. Hatchett could not determine its proportion. The pyrites he estimates at iron .68, sulphur .13, nickle .06, extraneous earthy matter .13. In the metallic particles disseminated through the mass, the nickel was in the proportion of 1 part, or thereabout, to 3 of iron. The hard separate bodies gave silex .50, magnesia .15, oxide of iron .34, oxide of nickel 0.25: and the cement, or matrix, silex .48, magnesia .18, oxide of iron .34, oxide of nickle .025. The increase of weight in both these arose from the higher oxidation of the iron. These proportions are taken from the stones that fell at Benares on the 19th of December, 1798.

The solitary masses of native iron, that have been found in Siberia, Bohemia, Senegal, and South America, likewise agree in the circumstance of being an alloy of iron and nickel; and are either of a cellular texture, or have earthy matter disseminated among the metal. Hence a similar origin has been ascribed to them.

Laugier, and afterward Thenard, found chrome likewise, in the proportion of about one per cent. in different meteoric stones they examined; but they appear not to have analysed the parts separately.

In all the instances in which these stones have been supposed to fall from the clouds, and of which any perfect account has been given, the appearance of a luminous meteor, exploding with loud noise, has immediately preceded, and hence has been looked to as the cause. The stones likewise have been more or less hot, when found immediately after their supposed fall. Different opinions, however, have been entertained on this subject, which is certainly involved in much difficulty. Some philosophers imagine them to be formed in the atmosphere by a sudden condensation of the elements of their component parts: others, that they already existed on the spot where they were found, and were merely struck by electric discharge: and professor Proust has suggested, that they might be torn from the polar regions by the meteor. Some have supposed them to be merely projected from volcanoes: while others have suggested, that they might be thrown from the moon; or be bodies wandering through space, and at length brought within the sphere of attraction of our planet.

We shall conclude this article with the instances that have occurred during the present century. On the 26th of April, 1803, a shower of stones, weighing from 18 lbs. to ⅔ of an ounce, and supposed to be two or three thousand in number, fell in the neighbourhood of l'Aigle, in Normandy, on a space about six miles long and two broad. On the 4th of July, a stone struck a house at East Norton, in England, with an explosion, by which the house was much damaged. On the 8th of September, a stone fell near Apt, in the country of Avignon. On the 13th of December, a stone fell on a barn at a small village in Germany, and broke the rafters of the roof. On the 5th of April, 1804, a stone fell at Possie, about three miles from Glasgow. And on the 15th of March, 1806, one fell at Valence, in the *arrondissement* of Alais, in France.

Professor Silliman examined a meteoric stone which fell in Connecticut, and the result was the same.

METHEGELIN.—A fermented beverage made from honey and water.

MEZZOTINTO SCRAPING. See ENGRAVING.

MEZZOTINTO PRINTS, *the art of painting with oil colours.*—Paste the print on a piece of clean, white, crown glass, which must be of the same dimension with the print; this is done in the following manner: first, take the mezzotinto print, and draw it through clean water; repeat this six or eight times, once every hour; then lay it between some moistened print-

ing-paper, and let it there remain all night: the next day set the glass before the fire, and, when it is warm, take some turpentine in a tea-cup, or a pipkin, and warm it over a clear fire; then take a large brush of hog's hair, and dipping it into the turpentine, spread it smooth and even upon the glass: then, the print being thoroughly soaked, take it out from between the paper, and lay it gently on the glass, beginning at one end, and proceeding gradually to press it gently down; and thus you go on till the whole print lies close, and you perceive no wind-bubbles between the paper and the glass. This being done, with your fingers roll and rub off all the paper, till you see no remains of it, but only the print on the glass: thus the most difficult task of the work is done. If the print is on a stubborn paper, then roll it up, tie it round with thread, and boil it in fair water, and that will make it fit for peeling. When the glass with the impression on it is thoroughly dry, have the oil-colours, of all the different sorts that painters use, placed on a palette, and paint the several parts with such as are suitable to them, on the back of the print, which will guide you by the out-line, where to break off one, and to begin another. the shadows of the print will make the shadow of your colour. But if you choose to have one deeper shadow added to what is already upon the glass, then let them be laid on first, and the lighter colour after, which you may blend together, so as to imitate a real painting. Whatever colours you lay on, let them be strong-bodied, that they may make the better appearance on the face of the glass.

MILD ALKALIS, or EARTHS.—The alkalis and lime are usually met with in combination with carbonic acid. Heat expels this substance from lime, and the alkalis are deprived of it by the superior attraction of pure quick lime, with which they are treated for this purpose. These practical operations were performed long before the existence and properties of carbonic acid were well ascertained. The alkalis and lime, when combined with carbonic acid, obtained the name of mild, from their slight action upon organized substances, compared with their action when deprived of it. In the latter state, they were said to be caustic. The terms caustic and mild are still frequently applied to the alkalis, and also to lime, magnesia, and barytes.

MILITARY FEATHERS. The manufacture of military feathers is carried on to a considerable extent in the United States; but none in the country appear to understand the business so well, including the branch of dyeing, as Mr. Littleboy and Mr. Tucker, who have obtained much celebrity in this city.

Before the feathers come into the hands of the person who makes them up for sale, they undergo several operations. They are curled, either by being baked, or by means of hot irons; and when necessary, they are also dyed.

The feathers principally in use are those of the ostrich, heron, the common cock, swan, peacock, and goose: of these, some are adapted to plumes, others are fitted for ornaments to the human head: to some we are indebted for the beds on which we lie, and to others for the pens with which we write.

Military feathers are chiefly made of the hackle feathers as they are called; these are plucked from the neck of the cock. The feathers of this bird are in great demand: his neck and back are clothed with long streaming feathers, intermixed with orange, black, and yellow; his tail is made up of stiff feathers, with two large ones waving over the rest in form of a sickle.

The plumage of the wonderful Indian cock is very beautiful and consists of five different colours, viz. the black, white, green, red, and blue; and the tail is made up of twelve very beautiful feathers. But ostrich feathers are the most valuable; in their natural state they are mostly black and white: the largest feathers are at the extremities of their wings and tails.

The feathers of the ostrich require dyeing and dressing before they can be used as ornaments.

Plume, or *plumage*, denotes the feathers of birds, which are frequently worn by military men, and females, as ornaments to the head-dress; a custom originally derived from barbarous nations.

White plumage may be effectually bleached by dipping it in the oxygenated muriatic acid, or bleaching liquor of Berthollet; and, this can be easily procured, by simply immersing it for a few hours in pure water acidulated with oil of vitriol, in the proportion of six or eight drops of the latter, to every ounce of the former; then drying the feathers in the sun, or at a distance from a fire.

The bleaching of plumes may be effected in a very simple manner, without much difficulty, in the following manner:—Mix in a bason equal parts of common salt and red lead, or in preference manganese of the shops: to this mixture add about half its weight of oil of vitriol previously diluted with a small quantity of water. Take the plume to be whitened, and, after wetting it in water, expose it to the fumes or gas arising from the mixture. In half an

hour or less time, the feather will become beautifully white. We have tried this plan, and, from its simplicity, we recommend it to feather workers. From the nature of the materials it is obvious, that the oil of vitriol disengages the marine acid from the common salt, which then becomes oxygenized from the red lead or manganese. The gas therefore disengaged, is the oxymuriatic. By combining with the water on the feather, it forms liquid oxymuriatic acid, and discharges the colour.

Variegated plumage may be cleaned and restored to its former brightness, by gently wiping it with a soft sponge dipped in spirits of wine; and, after it has been gradually dried, by moistening the downy part with a filtered solution of gum-arabic, or tragacanth;—then cautiously exposing the tops and sides to the heat of a bright fire, in orter to curl their extremities.

With respect to the art of dyeing feathers, we refer to the article DYEING

MILK. This fluid, the next in importance of all the animal liquors to blood, has been examined very largely by different chemists, and its analysis is curious and important.

Milk is a white opake fluid, varying in hue from a yellowish to a blueish tint, of a soft somewhat unctuous feel, and a sweetish and grateful taste. It frequently is altered in taste and smell, and sometimes too in colour, by the nature of the aliment which the animal takes. The specific gravity of milk varies according to the animal that produces it, the food, and other circumstances. The gravity of cows milk is about 1.0203 according to Brisson, and this is the lightest next to human milk. Sheeps milk, which is heavy, weighs 1.0409.

The chemical composition of this fluid is the same in all animals, as far as has been examined; that is, all milks consist of the same substances in intimate combination, but the relative proportion of these substances is probably not the same in any two animals, and is so remarkably different in some, as to be obvious to common observers. In a general view milk may be said to be composed of the following ingredients.

1. Of the caseous or curdy matter, which is separable from milk by various means, and particularly by rennet, and which when collected and condensed by pressure forms cheese.

2. Of a true animal oil, butter, which is separable from the cream chiefly by agitation.

3. Of a sweet watery fluid, the serum or whey, which generally contains a good deal of the two former ingredients dissolved, and also holds a quantity of saccharine matter, of animal jelly, of muriat of soda, and potash, and some phosphats.

Milk when moderately heated swells and froths considerably, and at about 200° of heat it boils. At the same time there forms on the surface a tough dry pellicle, which when removed is succeeded by another, and so on successively. This skin is the same as the curd or caseous matter obtained by the common means, and if the process is continued for a great length of time, all the curd may be separated in this form, and a watery liquid alone will remain.

If milk is evaporated to dryness there remains a solid yellowish extract, known abroad by the name of *franchipane*, and formerly used in medicine. If the vapour distilled from boiling milk be condensed in a proper receiver, it forms a clear liquor of a faintish taste, which after long standing becomes muddy and putrefies.

The coagulation of milk is one of the most important changes which it undergoes, and is effected by a variety of methods. All the acids coagulate milk, alcohol and all vinous liquors do the same, and also several vegetables. But the speediest and most perfect coagulation is effected by rennet, or an infusion of the stomach of calves, pickled and salted, which is the substance used in making cheese. The gastric juice of all animals also produces the same effect, and hence coagulation is the first process in the natural digestion of this fluid.

Coagulation is the most convenient method of analyzing milk, and it is thereby resolved into two principal portions, the coagulum or curd, and the whey. The analysis of each of these substances gives the following results.

Whey prepared by rennet (which is on the whole the best substance for coagulating milk for chemical analysis) when filtered and clarified is a limpid yellowish fluid, of a sweetish and rather saline taste, agreeable to most palates. Its specific gravity is somewhat less than that of the milk from which it is procured. Whey, when gently evaporated to the consistence of a syrup and allowed to cool undisturbed, deposits a singular crystalline sweetish matter called sugar of milk, which is prepared pretty largely in some of the Swiss cantons, and is used for culinary and medicinal purposes. To prepare it, fresh whey from skimmed milk is boiled down to the thickness of syrup, and then poured into earthen pots, where it solidifies and dries in the sun; this mass, which is brown and impure, is refined by re-so

lution, clarification with white of egg, and another evaporation, after which it concretes into white rhomboidal crystals.

Sugar of milk when pure is a white crystalline substance, of a sweetish and rather mawkish taste, soluble in four parts of boiling water and about twelve of cold. When strongly heated it turns brown, swells up and exhales the strong pungent vapour of burnt sugar, and finally leaves a black coal holding about one-thirtieth of its weight of salt, composed according to Rouelle, of three parts muriat of potash and one part carbonat of potash.

The phenomena attending the coagulation of milk by acids and by alcohol will be soon noticed; that by rennet is understood at present.

The curd of milk prepared by rennet, to be chemically pure, should be made of skimmed milk, otherwise it contains much of the butter and oily part. The consistence of curd depends on a number of minute circumstances, being sometimes quite soft and gelatinous, sometimes firm and as it were knotty. It is much condensed and hardened by heat. A long continued pressure is necessary, in order to separate entirely the adhering portion of whey. Curd (or cheese) from skimmed milk, when slowly dried in a moderate heat, becomes hard, brittle, and transparent like horn, which may be seen in some of the most ordinary cheeses as prepared for food. Whilst it retains its flexibility it is extremely tough and tenacious, and when heated it draws out into long strings. If the heat becomes scorching it melts, takes fire and burns with flame, smoke, and a fetid ammoniacal smell.

Curd is insoluble in water, but when long kept under cold water, it is changed to a soft fatty matter, considerably different from the original substance.

From all the properties of pure curd it appears to bear the strongest analogy with the white of egg, as Scheele observes, and it may be considered as nearly pure albumen, but mixed with a certain portion of phosphat of lime and a few other saline matters. Rouelle compared it to the gluten of wheat, which is also a just comparison, since there is also scarcely any ascertainable difference between pure gluten and pure albumen when each is in a condensed coagulated state. The effect of acids upon curd will be presently noticed.

Butter, or the oily part of milk, is well known to be prepared from cream by long agitation. New milk is perfectly homogenous, but on standing for some hours at rest it throws up a thick yellowish-white cream, unctuous to the touch, and of a very bland agreeable flavour. In the process of churning, the cream separates visibly into two substances, the butter which collects in a mass, and a thick white liquid, the buttermilk, as it is called, and whey; and still retains a little of the butter.

Butter is much more easily made from stale than from fresh cream, probably owing to the spontaneous change which cream undergoes by keeping, and the evolution of an acid. Butter often varies in colour, being of every shade from a faint yellowish-white to a deep yellow, but the cause of this variation is not very apparent. The action of the atmosphere has been thought by some to be concerned in the separation of cream from milk, and of butter from cream; but nothing in the least degree satisfactory has been brought in support of this opinion, and it is certain that agitation alone, in a corked bottle, will perfectly separate butter from cream.

Fresh butter melts at about 98°, and when kept for some time melted, a small quantity of serum and curd separate from it. The butter becomes thereby more transparent, but has acquired a less pleasant taste. Butter, when distilled *per se*, first gives over some water holding sebacic acid, after which the greater part of the butter rises with a pungent unpleasant smell, and fixes in the receiver into a concrete empyreumatic grease. A further distillation of this grease gives a finer and more volatile oil than at first, and other products similar to those of the animal oils, as will be further mentioned under the article Oil. Butter, when long kept, becomes excessively fetid and rancid; but this is in a great measure prevented by salting. Alkalies dissolve it with ease into a perfect soap.

On the whole, butter may be considered as most resembling the animal oils, but intimately combined with a small portion of the curd and whey, and other parts of the milk, from which probably it can never be separated without total disorganization; and, indeed, as milk is a natural emulsion elaborated in the vessels of the animal, the combination of its parts appears throughout to be so close, that it is scarcely in the power of art to break it entirely. Hence it is that we find the whey to retain almost to the last some of the curd and oil; the curd to be almost inseparable from the last portions of the whey and butter (to which much of the varieties of cheese is to be attributed) and

some of the curd and whey to remain in the composition of butter through every process.

All acids readily curdle milk; and, as appears from the experiments of Scheele, confirmed by those of Messrs. Fourcroy and Vauquelin, the coagulum thus formed consists of the curd united with a portion of the acid employed, insomuch that, if no more acid be used than is barely necessary, the whey shews no marks of acidity. The curd obtained by mineral acids (according to Scheele) is soluble in an excess of the acid, but not that produced by vegetable acids. If milk be previously mixed with ten parts of water, no curd is obtained by mineral acids; hence the cause of coagulation of undiluted milk in this case is, that the curd and acid together form a compound which requires for its solution much more water than the milk contains.

When milk is kept in a warm place, it is known to grow sour and thick in about two days, according to the temperature. This sourness daily increases, and is the strongest when about a fortnight has elapsed, and it then consists of a soft curd, acid and somewhat nauseous to the taste, and of whey highly sour and whitish. A strong acid is therefore generated in the process, which was first accurately examined by Scheele, who discovered that the acid differed from any other then known, and to which he gave the name of *Lactic Acid*.

Milk is susceptible of the vinous fermentation, so as to be made to yield an ardent spirit by subsequent distillation; but it is not very easy to ferment milk, and it always turns sour at the same time. The Tartars and other Asiatic nations have been from time immemorial in the habit of preparing an intoxicating liquor from mare's milk. This is called *koumiss*, and the process is thus given by Dr. Grieve. Take any quantity of mare's milk, dilute it with a sixth of water, pour it into a wooden vessel, and add as a ferment about one-eighth of very sour milk, or better, of old koumiss; cover the vessel with a thick cloth, and keep it in a moderate temperature. After standing twenty-four hours, a thick coagulum rises to the top, which must be well mixed by beating. After reposing for another day, it is again stirred till it becomes quite homogeneous, and in this state it forms the koumiss, which has an agreeable sweetish acescent taste.

Milk in the state of koumiss does not easily change by keeping. By distillation it yields a considerable quantity of alcohol, as much (according to Pallas) as one-third of its bulk. The entire milk appears essential to the production of ardent spirit, as well as frequent agitation to mix the constituent parts which the acid has caused to separate.

Though the milk of different animals is found to be essentially the same in the number and chemical nature of the several ingredients (as far as has been examined) yet a very considerable difference is found in the proportion of these substances and in some of their sensible properties. The experiments of Parmentier are particularly curious on this subject. The kinds of milk that he examined were, first, cow's milk, as a standard, to which were compared the following, viz. woman's, asses', goat's, ewe's, and mare's milk.

Woman's milk is sweeter than cow's, and thinner; but it is of all others, that which varies most according to the state of body, constitution, age, &c. of the person whence it is drawn. The cream is on the whole more copious than of common cow's milk, but it differs peculiarly in this, that neither agitation nor any other known means will entirely separate the butter; the utmost effect of these means being only to give the whole cream somewhat of an unctuous consistence, without effecting any separation into butter, curd, and whey.

Human milk also deposits part of its curd by mere rest, which is found sticking to the sides of the vessel which holds it. Though sweeter to the taste than cow's milk, it does not contain, sensibly, more sugar.

Asses' milk more resembles the human than any other. The cream is in small quantity, by agitation it gives a butter which is soft, white, and nearly tasteless. It soon becomes very rancid, owing probably to its retaining a portion of the acid. By standing, it deposits much of the curd, even before it becomes sour.

Goat's milk is very thick, yellowish, and pleasantly flavoured. It is somewhat denser than cow's milk. The cream is remarkably thick and unctuous, and will keep a long time without growing sour or sensibly changing. By agitation it gives a very firm, solid, and white butter, to appearance very free from all admixture. The milk also abounds in curd, so that, when heated, a much thicker pellicle rises, and, when coagulated by any of the usual methods, the curd is so abundant, that the whey is with difficulty separable. It is also of a very gelatinous dense consistence. The sugar of milk is small in quantity, but separates with ease.

Sheep's milk resembles cow's very closely in taste and appearance. It yields abundance of cream, which by churning affords much butter, but which always remains very soft. The quantity of curd is remarkably large, and it has a very fat and unctuous appearance, and a taste which is peculiar to it, and is always very distinguishable in ewe-milk cheese.

Mare's milk is thin and insipid, and does not coagulate with vinegar. It is remarkable for the small quantity of cream which it gives, and the extreme difficulty of separating the butter from it by agitation. The whey contains sulphat of lime, which has not been found in any other milk.

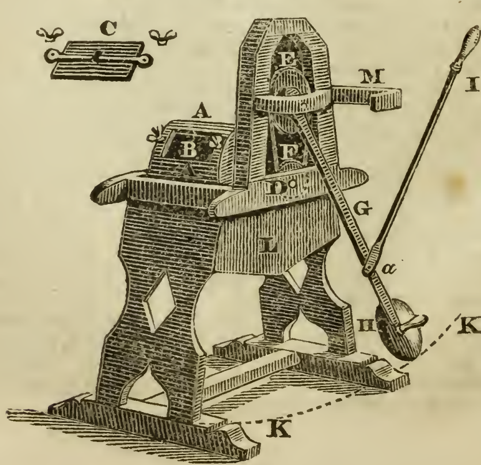
The above-mentioned species of milk all resemble each other essentially in the number and general chemical nature of the ingredients, but great diversity appears in their respective proportion, and apparently in the mode of mixture. Thus with regard to the cream, cow's and sheep's milk yield it easily by repose, its consistence is greater than in the others, and the butter separates more perfectly. There is an equal difference in the consistence of the curd, that from cow's and sheep's milk being dense, and readily separating by the usual coagulating substances, but the curd from ass's and mare's milk always remains thin, and almost of a creamy consistence.

In relation to the subject of milk, we shall here introduce some remarks on churns, with one or two drawings.

Mr. William Bowler's improved *churn*, is of the barrel kind, being a cylinder, 18 inches in diameter, and 9 wide; the sides are of wood, the rim a tin plate, which has two openings; one 8½ inches in length, and 4 in width, through which the cream is poured into the churn, and the hand introduced for cleaning it; the other, a short pipe, one inch in diameter, by which the butter-milk runs out of the churn, when the operation is finished. The first of these openings has a wooden cover, fastened down by two screws; and the other a cork fitted to it, while the butter is churning. There is farther, near the larger opening, a small vent-hole, with a peg to admit the passage of any air that may be discharged from the cream, at the beginning of the operation. An axle also passes through the churn, terminating in two gudgeons, on which it hangs; its lower part being immersed in a trough, in order to hold occasionally either hot or cold water, according to the season of the year. On the inside of the rim, are four projecting pieces of wood, with holes, serving to agitate the cream by the motion of the churn. This movement is caused by a pendulum 3 feet 6 inches long, that has an iron bob, weighing 10 lbs. and at its upper end a turning pulley, 10 inches in diameter, from which a rope goes twice round another pulley, about 3 inches in diameter, fixed on the axis of the churn, which it causes to make a partial revolution, by each vibration of the pendulum.

There are likewise sliding covers to the machinery, and also another to the water trough; in order, when hot water is used, to secure the steam, and keep the cream in a proper degree of warmth. The motion of the pendulum is given, and continued, by means of a wooden rod, about 3 feet 9 inches in length, which turns on a pin 3 inches above the bob of the pendulum.

BOWLER'S IMPROVED CHURN.



Explanation of the Cut which represents Mr. William Bowler's improved Churn.

A. A The body of the churn, of tin.

B. An opening by which the cream is put in.

C. The cover of the large opening. The small hole on the opposite side cannot be delineated in the print.

D. The axis, or gudgeon, on which the body of the churn is suspended.

E. The upper, or large pulley.

F. The smaller pulley fixed on the axis of the churn.

G. The rod of the pendulum, hanging from the upper pulley E.

H. The bob of the pendulum.

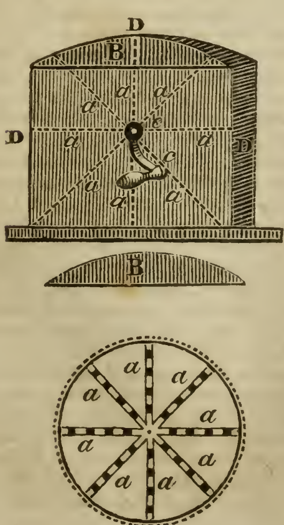
I. The handle, moveable on the pin at *a*, by which the pendulum is moved, making a traverse in the form of the dotted line K. K.

L. The trough for the hot or cold water. To be made of tin, because a better conductor of heat than wood.

M. A projecting piece of wood, with a shoulder, which supports the handle I, when the churn is not at work.

As butter is often made in small quantities, and the vertical motion of the common churn is extremely fatiguing, we consider those methods of applying the powers of mechanism, as valuable improvements. Hence we presume to recommend the improved butter-churns to be generally introduced; for the facility and expedition with which butter is thus obtained, will amply compensate the additional expense.

WRIGHT'S CHURN.



This churn is made in the form of a cube, with vertical dashers, as *a, a, a, a, a, a, a, a*; B, the top that takes off; C, the handle by which the dashers are turned; D, D, D, the form of the churn each way; C, the spindle that goes through the dashers.

MILK PAINT. See Colour Making.

MILL.
MILL-WORK.
MILL MACHINERY. } See Mechanics.

MILL-STONE. The large circular stone used in mills, for the purpose of grinding grain, or corn, into flour. Mill-stones are made in the United States, but none superior to those manufactured by Mr. Oliver Evans, of this city. The burr stone is found in Georgia, and in the Western Country. The acquisition of this stone, may be considered as very valuable, from its extensive utility in the manufacture of flour.

These stones were formerly imported in great numbers from France: the burr-stones of that country having been found harder and more durable. To prevent the expense, the Patriotic Society for the Encouragement of Arts, &c. in Britain, offered a liberal premium for the discovery of a quarry of mill-stones similar to the French burrs; which desirable object was attained in 1799, by Mr. Richard Bowes, of Conway, in North Wales, to whose widow the Society, in 1800, voted the reward of 100l.

In the year 1796, a patent was granted to Mr. Major Pratt, for his invention of a method of manufacturing a composition-stone, calculated for grinding corn, and various other articles, in the same manner as is effected by the common mill-stones. His artificial compound is stated to consist in mixing certain proportions of siliceous and argillaceous earths (that can only be ascertained by practice,) with about one-seventh part of calcareous earth. These are exposed to a fire, heated to the degree usually required in calcining lime, for the space of twenty-four hours, or such farther period as experience alone can determine; after which the composition may be formed into durable stones. The Georgia burr, however, answers every purpose in the United States.

For sundry observations on mill-stones, see Mechanics.

MINERAL WATERS. See Water.

MINERALIZER. See Ore, Metallurgy.

MINES. See Metallurgy.

MINIUM. See Lead.

MIRROR.—A *mirror*, or *speculum*, is an opaque body, whose surface is very

smooth and finely polished, so that it will reflect the rays of light which fall upon it, and by this means represent the images of objects opposed to it

Mirrors are generally made of metal, or glass polished on one side and silvered on the other, and are either *plain*, *convex*, or *concave*.

Plain mirrors, are those whose surfaces are perfect planes, and whose section is a straight line; such are vulgarly called *looking-glasses*.

Convex mirrors, are those whose middle parts are more prominent than their extremities or edges; and whose sections are curves which may be either circular, elliptical, parabolical, or hyperbolical

Concave mirrors, are those whose surfaces sink in with a hollowness. See GLASS, SPECULUM, SILVERING.

MOHAIR, MOREE.—The Mohair goats are a variety of the common goats, being famous for their soft and silver white hairs, the like of which are not to be found in any place but Angora. This hair is commonly carried ready spun to Europe, and being there woven into camlets and other manufactures, particularly by the English, is afterwards exported to all parts of the world, and even to those whence the yarn was originally brought.

MOLASSES. See MELASSES

MOLYBDENA.—Molybdena is a metal of a greyish white colour, in the form of brittle infusible grains. It is convertible to a yellowish white oxyd by exposure to the air at a red heat, or by the action of nitric acid.

Ores of Molybdena.

Sp. 1. Molybdena, or Sulphuret of Molybdena.

Sp. 2. Molybdat of Lead. Yellow Lead-spar.

Reduction of Ores.—Physical properties of Reguline Molybdena.

As molybdena is a metal that has not hitherto been applied to any use, so there has been no attempt in the great way to reduce its ores. The complete decomposition of the acid or oxyd of this metal has, however, been undertaken by various chemists, and for the most part with but little success. The chief cause of failure seems to have been, that the substance operated on, instead of being the pure metallic acid, has also contained a portion of fixed alkali, which, by its affinity for the acid, most powerfully opposes its deoxydation. The method that as yet has been attended with the most satisfactory results, is that published by Helm. The acid being made into a paste with linseed oil, is to be exposed to a strong heat in a covered crucible; being then withdrawn from the fire, the black mass is to be pulverized, and again mixed with oil, and torrefied as before; by repeating this two or three times, the molybdena is completely reduced, and assumes its proper metallic lustre. It appears highly probable, that the method which has been successfully practised in the reduction of tunstic acid, would be equally efficacious with the molybdic acid. It is the following. Let the pure molybdic acid be combined with as much ammonia as possible, and then exposed to an intense heat, in a crucible lined with charcoal: the ammonia would be decomposed, and its hydrogeneous base, together with the charcoal, would probably carry off the whole of the oxygen from the metal.

Molybdena, in the only state in which it has hitherto been procured, is a very loosely adhering aggregate of minute grains of a yellowish white colour and metallic lustre. When recently broken it exhibits a greyish white colour. It is hard, very brittle, and difficultly fusible. Sp. gr. 7.5.

Molybdena, or sulphuret of molybdena, has been discovered in this state, Chester county, but the metal is not used in the arts.

MORDANT. See DYEING.

MOROCCO LEATHER. See LEATHER.

MORTAR. See CEMENT.

MOSAIC GOLD. See COPPER.

MOSAIC WORK.—Under the name of mosaic-work are included such performances as relate to inlaid work; as tablatures of stone, wood, metals, &c. What we are now treating upon is that which represents not only all manner of figures, in their proper colours, attitudes and shapes, as large as those that are lasting ornaments in churches, and other public edifices, but also in small, and fit to grace the cabinets of the great and curious, and imitate a picture painted in miniature.

The antients, who practised this art with much skill and exactness, have left a variety of their performances, which are found not only in Italy, Spain, &c. but also in England. Those remaining at Rome are the finest, in the temple of Bacchus, now the church of St. Agnes; and there are also curious pieces to be seen at Venice, Pisa, Florence, and other places.

The modern artists have improved very much in this performance, and whatever traveller has been at St. Peter's and the palace of Borghese at Rome, St. Mark's at Venice, and the church of St. Felicia at Florence, will confess they have seen wonders.

Such figures are composed, jointed and cemented together of various coloured stones; but since nature has scarcely, at least not sufficiently, supplied the proper shades requisite for a masterly performance, that defect has been made up by counterfeiting those colours, by art, in glass; which is done in the following manner:

The glass materials are put in the crucibles or melting pots, and being in fusion, such a colour is added as would make the shades, in the manner directed, in the art of making artificial gems; beginning with the lightest. See GLASS. Having mixed it well, and taken out the quantity you think proper with an iron ladle, put it on a smooth marble, flatting it with another to a proper thickness; then cut it quickly into small pieces, laying them, when cold, in a box for use: add more colour, and proceed as before, repeating it till you come to the deepest shade. If you would gild them, wet them on one side with gum-water, and lay leaf gold upon them; and in an iron shovel, covered with pieces of other glass, heat them red hot in the mouth of a furnace; then take them out, and when cold, the gold will be so fixed and firm that nothing can hurt it.

When you begin to work, lay a thick ground against the cieling or wall, with plaster, and having your design ready drawn and painted on blue or brown paper, clap part of it upon the wet plaster, and with a pair of small pliers, take up the small stones, and press them in their proper places; forming the figures and shades in their respective colours, as you are directed by your painted model. In this manner is done the history of "*Our Saviour's walking with Peter on the sea,*" in St. Peter's church at Rome.

Stones cut in squares, and of different colours, imbedded in cement, and arranged according to fancy, form the Mosaic pavements of ancient temples, mausoleums &c., specimens of which, may be seen in Peale's museum.

MOSS. See ARCHIL, LITMUS.

MOTHER WATER. See SALT, &c.

MOULD. See AGRICULTURE.

MOULDS, *to make, for Paper-frames, and other things, as fine as if fresh carved.* IMISON.

Take shavings of paper, and soak them in clean water for the space of six or eight days; then boil them for about two hours in clean water; this done, take them out of the pot, with as little moisture as possible, and stamp them in a stone mortar, to a paste. When it is fine enough, let it settle; pour off the water if any remains, and put the stamped paper into a linen bag, tied close: hang it in fair water, and keep it there till you have occasion to make use of it, shifting the water once a week, and it will keep good for twelve months together. When your mould is ready, you may at any time take off the said stamped paper, wringing out the water, and, tempering it with a little size, of what colour you please; put it on the mould, and with a spunge press it down, and soak up the superfluous moisture from it. Having thus filled the mould, set it in the sun, or a warm room, and, when dry, it will easily come off the mould, and be like plaster of Paris, of a beautiful white. You may afterwards paint or gild it, or make any use of it you intended. It will make frames to pictures; likewise paper-hangings, snuff-boxes, and many other things. You may cover them with a clear hard varnish.

MOULDING AND CASTING.—The art of taking casts or impressions from pieces of sculpture, medals, &c. is of very great importance in the fine arts. Many excellent impressions have been made in this country by some of our own artists, equal in every respect to the foreign. Witness the elegant bust of the late professor Rush, the mould of which was made by Mr. William Rush, the carver.

In order to procure a copy or cast from any figure, bust, medal, &c. it is necessary to obtain a mould, by pressing upon the thing to be moulded or copied some substance which, when soft, is capable of being forced into all the cavities or hollows of the sculpture. When this mould is dry and hard, some substance is poured into it, which will fill all the cavities of the mould, and represent the form of the original from which the mould was taken.

The particular manner of moulding depends upon the form of the subject to be worked upon. When there are no projecting parts, but such as form a right or a greater angle with the principal surface of the body, nothing more is required than to cover it over with the substance of which the mould is to be formed, taking care to press it well into all the cavities of the original, and to take it off clean, and without bending.

The substances used for moulding are various, according to the nature and situation of the sculpture. If it may be laid horizontally, and will bear to be oiled without injury, plaster of Paris may be advantageously employed, which may be poured over it to a convenient thickness, after oiling it, to prevent the plaster from sticking. A composition of bees-wax, resin, and pitch, may also be used, which will

be a very desirable mould, if many casts are to be taken from it. But if the situation of the sculpture be perpendicular, so that nothing can be poured upon it, then clay, or some similar substance, must be used. The best kind of clay for this purpose is that used by the sculptors for making their models with; it must be worked to a due consistence, and having spread it out to a size sufficient to cover all the surface, it must be sprinkled over with whiting, to prevent it from adhering to the original. Bees-wax and dough, or the crumb of new bread, may also be used for moulding some small subjects.

When there are undercuttings in the bas-relief, they must be first filled up before it can be moulded, otherwise the mould could not be got off. When the casts are taken afterwards, these places must be worked out with a proper tool.

When the model, or original subject, is of a round form, or projects so much that it cannot be moulded in this manner, the mould must be divided into several parts, and it is frequently necessary to cast several parts separately, and afterwards to join them together. In this case, the plaster must be tempered with water to such a consistence, that it may be worked like soft paste, and must be laid on with some convenient instrument, compressing it so as to make it adapt itself to all parts of the surface. When the model is so covered to a convenient thickness, the whole must be left at rest till the plaster is set and firm, so as to bear dividing without falling to pieces, or being liable to be put out of its form by any slight violence; and it must then be divided into pieces, in order to its being taken off from the model, by cutting it with a knife with a very thin blade; and being divided, must be cautiously taken off, and kept till dry: but it must be observed, before the separation of the parts be made, to notch them across the joints, or lines of division, at proper distances, that they may with ease and certainty be properly put together again. The art of properly dividing the moulds, in order to make them separate from the model, requires more dexterity and skill than any other thing in the art of casting, and does not admit of rules for the most advantageous conduct of it in every case. Where the subject is of a round or spheroidal form, it is best to divide the mould into three parts, which will then easily come off from the model; and the same will hold good of a cylinder, or any regular curve figure.

The mould being thus formed, and dry, and the parts put together, it must be first oiled, and placed in such a position, that the hollow may lie upwards, and then filled with plaster mixed with water; and when the cast is perfectly set and dry, it must be taken out of the mould, and repaired when necessary, which finishes the operation.

In larger masses, where there would otherwise be a great thickness of the plaster, a core may be put within the mould, in order to produce a hollow in the cast, which both saves the expense of the plaster, and renders the cast lighter.

In the same manner, figures, busts, &c. may be cast of lead, or any other metal in the moulds of plaster or clay; taking care, however, that the moulds be perfectly dry; for, should there be any moisture, the sudden heat of the metal would convert it into vapour, which would produce an explosion by its expansion, and blow the melted metal about.

On the subject of statuary, as connected with this subject, we shall offer the following observations:

When a statue is to be formed of stone, marble, &c. a drawing is first made of the subject intended to be carved; a model is next made, by laying a mass of moist clay on a board, and reducing it to shape and form with knives and spattles. Sometimes a model is made without any previous drawing, and sometimes the stone is cut from a drawing without a model.

The marble or stone is carved with steel chisels of different sizes, and a wooden maul. The statue is not made in a single piece, but of several; which, when finished, are fastened together, with a cement f the powder of calcined alabaster, called plaster of Paris; this is mixed with water to the thickness of batter, which in a short time becomes as hard as the marble itself, and is as durable.

The Parian marble is the most celebrated; and from this, which is of a most beautiful white, the greatest part of the Grecian statues were made. It is also called *statuary* marble, and is generally supposed to have had its name from the island Paros, one of the Cyclades in the Ægean sea, where it was found; by others the name is derived from Agoracritus Parius, a famous statuary, who gave it celebrity by cutting a statue of Venus from it. See Marble.

Among the many statues of antiquity cut out of this marble, is that of Laocoon and his two sons, which is mentioned by Pliny, and has escaped the injuries of time.

Almost all white marbles now go under the name of Parian marble; and among

the workmen they have the common name of alabasters, though they come from different places, as from Spain, some parts of France, Italy, &c. Marble is also found in this country.

Dædalus has been celebrated as the inventor of statues, but it is certain that there were statuaries before his time. He was, however, the first person that found the method of making them appear as if they were alive. Till his time statues were made with their feet joined together: he loosened their feet, and gave them the attitudes of people walking and acting.

Statues are usually distinguished into four general kinds. The *first* are those less than life, of which kind are the statues of great men, of kings, and of the gods themselves. The *second* are those equal to the life; with these the ancients celebrated the deeds of men eminent for learning or valour. The *third* are those that exceed life; among which some surpassed the life once and a half: these were for monarchs and emperors, and those double the life for heroes. The *fourth* kind were still larger: these were called colossuses, or colossal statues. Of this last, the most eminent was the colossus of Rhodes, one of the wonders of the world, a brazen statue of Apollo, so high, that ships passed in full sail between its legs. It was the workmanship of Chares, who spent twelve years in making it.

To take a Cast in Metal, from any small Animal, Insect, or Vegetable.

Prepare a box of four boards, sufficiently large to hold the animal, in which it must be suspended by a string, and the legs, wings, &c. of the animal, or the tendrils, leaves, &c. of the vegetable, must be separated, and adjusted in their right position by a pair of small pincers. A due quantity of plaster of Paris mixed with talc, must be tempered to the proper consistence with water, and the sides of the box oiled. Also a straight piece of stick must be put to the principal part of the body, and pieces of wire to the extremities of the other parts, in order that they may form, when drawn out after the matter of the mould is set and firm, proper channels for pouring in the metal, and vents for the air, which otherwise, by the rarefaction it would undergo from the heat of the metals, would blow it out, or burst the mould. In a short time the plaster will set, and become hard, when the stick and wires may be drawn out, and the frame or coffin in which the mould was cast taken away: and the mould must then be put, first, into a moderate heat, and, afterwards, when it is as dry as can be rendered by that degree, removed into a greater, which may be gradually increased, till the whole be red hot. The animal or vegetable inclosed in the mould, will then be burnt to a coal; and may be totally calcined to ashes, by blowing for some time into the charcoal and passages made for pouring in the metal, and giving vent to the air, which will, at the same time that it destroys the remainder of the animal or vegetable matter, blow out the ashes. The mould must then be suffered to cool gently, and will be perfect, the destruction of the substance included in it, having producing a corresponding hollow; but it may nevertheless be proper to shake the mould, and turn it upside down, as also to blow with the bellows into each of the air vents, in order to free it wholly from any remainder of the ashes; or where there may be an opportunity of filling the hollow with quicksilver, it will be found a very effectual method of clearing the cavity, as all dust, ashes, or small detached bodies, will necessarily rise to the surface of the quicksilver, and be poured out with it. The mould being thus prepared, it must be heated very hot, when used, if the cast is to be made with copper or brass, but a less degree will serve for lead or tin. The metal being poured into the mould, must be gently struck, and then suffered to rest till it be cold; at which time it must be carefully taken from the cast, but without force; for such parts of the matter as appear to adhere more strongly, must be softened by soaking in water till they be entirely loosened, that none of the more delicate parts of the cast may be broken off or bent.

When talc cannot be obtained, plaster alone may be used; but it is apt to be calcined by the heat used in burning the animal or vegetable from whence the cast is taken, and to become of too incoherent and friable a texture. Stourbridge, or any other good clay, washed perfectly fine, and mixed with an equal part of fine sand, may be employed. Pounded pumice-stone, and plaster of Paris, in equal quantities, mixed with washed clay in the same proportion, is said to make excellent moulds.

Method of taking a Cast in Plaster from a person's face.

The person whose likeness is required in plaster, must lie on his back, and the hair must be tied back, so that none of it covers the face. Into each nostril convey a conical piece of stiff paper open at both ends, to allow of breathing. The face is then lightly oiled over in every part with

salad oil, to prevent the plaster from sticking to the skin. Procure some fresh-burnt plaster, and mix it with water to a proper consistence for pouring. Then pour it by spoonfuls quickly all over the face (taking care the eyes are shut), till it is entirely covered to the thickness of a quarter of an inch. This substance will grow sensibly hot, and in a few minutes will be hard. This being taken off, will form a mould, in which a head of clay may be moulded, and therein the eyes may be opened, and such other additions and corrections may be made as are necessary. Then, this second face being anointed with oil, a second mould of plaster must be made upon it, consisting of two parts joined lengthwise along the ridge of the nose; and in this a cast in plaster may be taken, which will be exactly like the original.

To take Casts from Medals.

In order to take copies of medals, a mould must first be made; this is generally either of plaster of Paris, or of melted sulphur.

After having oiled the surface of the medal with a little cotton, or a camel's-hair pencil dipped in oil of olives, put a hoop of paper round it, standing up above the surface of the thickness you wish the mould to be. Then take some plaster of Paris, mix it with water to the consistence of cream, and with a brush rub it over the surface of the medal, to prevent air-holes from appearing; then immediately afterwards make it to a sufficient thickness, by pouring on more plaster. Let it stand about half an hour, and it will in that time grow so hard, that you may safely take it off; then pare it smooth on the back and round the edges neatly. It should be dried, if in cold or damp weather, before a brisk fire. If you cover the face of the mould with fine plaster, a coarser sort will do for the back; but no more plaster should be mixed up at one time than can be used, as it will soon get hard, and cannot be softened without burning over again.

Sulphur must not be poured upon silver medals, as this will tarnish them.

To prepare this mould for casting sulphur or plaster of Paris in, take half a pint of boiled linseed-oil, and oil of turpentine one ounce, and mix them together in a bottle; when wanted, pour the mixture into a plate or saucer, and dip the surface of the mould into it; take the mould out again, and when it has sucked in the oil, dip it again. Repeat this, till the oil begins to stagnate upon it; then take a little cotton wool, hard rolled up, to prevent the oil from sticking to it, and wipe it carefully off. Lay it in a dry place for a day or two (if longer the better) and the mould will acquire a very hard surface from the effect of the oil.

To cast plaster of Paris in this mould, proceed with it in the same manner as above directed for obtaining the mould itself, first oiling the mould with olive-oil. If sulphur casts are required, it must be melted in an iron ladle.

Another method with Isinglass.—Dissolve isinglass in water over the fire; then with a hair-pencil, lay the melted isinglass over the medal; and when you have covered it properly, let it dry. When it is hard, raise the isinglass up with the point of a penknife, and it will fly off like horn, having a sharp impression of the medal.

The isinglass may be made of any colour, by mixing the colour with it; or you may breathe on the concave side, and lay gold leaf on it; which, by shining through, will make it appear like a gold medal. But if you wish to imitate a copper medal, mix a little carmine with the isinglass, and lay gold leaf on as before.

To colour Plaster.

Plaster of Paris may be tinged with several colours, when you are casting, by mixing with it Prussian blue, red lead, or yellow ochre, with which you may compose a blue, red, yellow, and green. As the coloured plaster takes a little more time to dry than when it is unmixed, you may sift some dry plaster upon the back of the casts when in the mould, which will make them dry quicker.

To make Sulphur red or green, or to make it resemble Marble.

Take two ounces of the best clean stone brimstone, and melt it slowly over a gentle fire, without letting it flame; when it is melted, add one ounce of vermilion; stir them well together; then pour the composition over the surface of your mould, and immediately pour it off again, and fill the mould up to a proper thickness with common brimstone: let it stand the same time as before mentioned, then pare it, and rub over the surface with some clean cotton, which will give it a polish. The more impressions you can make at one melting the better, because the brightness of the red fades the oftener it is melted. It may be made green by adding the same quantity of the best smalt instead of vermilion; only it requires more stirring to mix it properly. It may also be made to imitate a beautiful marble, thus: Mix with it several colours separately, and make them into small squares

of equal sizes; dispose them according to your fancy, endwise, in an iron frame that will open with a joint; after which melt them together, and the colours will unite in a pleasing manner, and each will appear distinct. When you melt it, be careful not to shake it, and let it cool by degrees.

Sulphur may also be made to have a metallic appearance, by rubbing it over with powder of black lead.

MOULDING CARVING IN WOOD, *the Art of, according to* LENORMAND, *Professor of Natural Philosophy in the Central School of the Department of Tarn*.—"I made (says he) very clear glue with five parts of Flanders glue, and one part of fish glue or isinglass. I dissolved these two kinds of glue separately in a large quantity of water, and mixed them together after they had been strained through a piece of fine linen to separate the filth and heterogeneous parts which could not be dissolved. The quantity of water cannot be fixed, because all kinds of glue are not homogeneous, so that some require more and some less. The proper degree of liquidity may be known by suffering the mixed glue to become perfectly cold: it must then form a jelly, or rather a commencement of jelly. If it happens that it is still liquid when cold, a little of the water must be evaporated by exposing the vessel in which it is contained to heat. On the other hand, if it has too much consistence, a little warm water must be added. In a word, the proper degree will be ascertained by a few trials.

The glue thus prepared, is to be heated till you can scarcely endure your finger in it: by this operation a little water is evaporated, and the glue acquires more consistence. Then take fine raspings of wood or saw-dust, sifted through a fine hair sieve, and form it into a paste, which must be put into moulds of plaster or sulphur, after they have been well rubbed over with linseed or nut-oil, in the same manner as when plaster is to be moulded. Care must be taken to press the paste in the mould with your hand, in order that it may acquire all the forms of the mould: then cover it with an oiled board, and, placing over it a weight, suffer it in that manner to dry. The desiccation may be hastened and rendered more complete by a stove. When the impression is dry, remove the rough parts, and if any inequalities remain behind they must be smoothed; after which the impression may be affixed with glue to the article for which it is intended. Then cover it with a few strata of spirit of wine varnish, as is done in general in regard to carved work, or with wax in the encaustic manner. It requires much attention to discover that such ornaments are not carved in the usual manner. Gilding may be applied to them with great facility. This operation is exceedingly easy; nothing is necessary but moulds; and with a little art the ornaments may be infinitely varied

I tried also to mould figures, and completely succeeded. These, however, require more care. I first make a paste, similar to the former, with very fine sawdust, and place a stratum, of about two lines in thickness, on every part of the mould; after which it is left to dry almost entirely. In the mean time I prepare a coarse paste, with coarse sawdust, which has not been made to pass through a fine but a coarse sieve, and instead of Flanders glue I employ common glue, which is less expensive, adding to it a sixth of fish glue. I first put together two parts of the mould, after introducing into the joints a slight stratum of the fine paste, which I make very clear, and apply with a small brush. I fill up the vacuity between the two pieces with coarse paste. I then apply the third piece as I did the second, and so on until the whole are adjusted, always filling up the vacuities with coarse paste. I suffer the whole to dry in the mould, and obtain a figure in relief of solid wood, executed with all the delicacy of plaster figures. Care must be taken to remove with a sharp knife, or a small file, the prominences formed by the joinings. If the figure be not suffered to dry too much, these prominences may be easily removed with the point of a sharp penknife. It will be necessary to learn the art of determining the proper degree of desiccation; for if the figure be taken from the mould before it is properly dried it will become warped, and if it be too dry it cannot be corrected but with a file, which is tedious and laborious, whereas if the proper moment be seized the paste may be cut like wax; especially if the sawdust has been fine, which is necessary for the exterior strata. The figures may then be completely dried in a stove, by which means they will acquire a degree of desiccation and solidity hardly to be conceived. Figures thus moulded may be bronzed, or varnished; they will then be unalterable by the effects of moisture or dryness.

I have already said, he concludes, that Flanders, and not common glue, ought to be employed for the exterior strata, because this glue is almost colourless;

whereas the other, being dark-coloured, gives too obscure a tint even to walnut-tree wood.

MUCILAGE, a substance valuable in water, whether hot or cold, with which it forms a transparent adhesive or gluey mass. Vegetable substances usually receive the name of gum, and animal substances affords a substance called glue. See GELATIN, &c

The purest of the gum-mucilages is Gum-Arabic or Senegal, which forms a very valuable article of commerce to the countries that yield it. An inferior sort of gum for the purposes of manufacture, but closely resembling gum-arabic in every property, is that which exudes from cracks in plumb, peach, pear, and other fruit trees, and has generally the colour of amber. Besides these sources of gum-mucilage, there are many vegetables whose native juices so much abound with mucilage, that a considerably pure and solid gum may be obtained by simple decoction of the plant, and evaporation to dryness. Several of the lichens, the leaves of the comfrey and mullen, the root of the hare-bell, and the whole plant of the marsh-mallow, afford a good mucilage in this method.

We shall first give a short account of the gathering of the gum-senegal, before we proceed to the chemical properties of mucilage. The gum-arabic is obtained in a similar manner, and Cairo and Alexandria were the principal marts for this gum, till the Dutch introduced the gum from Senegal into Europe, about the beginning of the seventeenth century, and which now supplies the greater part of the vast consumption of this article.

The tree which yields this gum is a species of mimosa, which grow abundantly on the sands along the whole of the Barbary coast, and particularly about the river Senegal. There are several species, some of which yield a red astringent juice, which, when inspissated, forms the *Catechu*, but others afford only a pure nearly colourless insipid gum, which is the great article of commerce. These trees are from 18 to 20 feet high, with thorny branches. The gum makes its appearance about the middle of November, when the soil has been thoroughly saturated with the periodical rains. The gummy juice is seen to ooze through the trunk and branches, and in about a fortnight it hardens into roundish drops of a yellowish-white, which are beautifully brilliant where they are broken off, and entirely so when held in the mouth for a short time to dissolve the outer surface. No clefts are made, nor any artificial means used by the Moors to solicit the flow of the gum. The lumps of gum-senegal are usually about the side of partridge eggs, and the harvest continues about six weeks. The quantity annually sold out of the Senegal country for European consumption, is about twelve hundred thousand pounds weight.

This gum is also a very wholesome and nutritious food, thousands of the Moors supporting themselves entirely upon it during the time of harvest. About six ounces is sufficient to support a man for a day, and it is besides mixed with milk, animal broths, and other victuals.

The gum-arabic, or that which comes directly from Egypt and the Levant, only differs from the gum-senegal in being of a lighter colour and in smaller lumps, and it is also somewhat more brittle. In all other respects the two resemble each other perfectly. Its specific gravity is about 1.45.

The uses of this gum are very great and numerous. The greatest consumption of gum-senegal is in furnishing a thick viscid fluid, with which the different mordants are mixed in calico-printing, which has been more particularly described in the article *Dyeing*.

Another great use of gum-arabic is in giving a fine gloss or glazing to ribbons and silks. For this purpose a thin solution is made, and the silk slightly brushed over with it, and when dry it leaves a very thin colourless varnish, but readily washed off by water, whence the spotted appearance that a shower of rain gives to these articles. Gum-arabic is also used as a clean, convenient, and pretty strong cement for an infinite number of purposes where there is no risk of moisture. Its ready solubility in water, and the length of time which the solution will keep without spoiling, render it highly valuable in the arts

This gum is also employed in pharmacy, as a very convenient way of rendering miscible with water, oils, resins, and other substances, on which water alone has no action. The effect here is chiefly mechanical. The substance (olive oil for example) is to be well rubbed with about half its weight of a strong solution of gum, and the watery liquid afterwards added by degrees, and with constant rubbing; and by this method an opake emulsion is formed, in which the substances will remain mixed for many hours, nor will they again entirely separate.

To obtain the gum-mucilage from those vegetables that do not yield it by exsuda-

tion, recourse must be had to boiling with water, and evaporation. These kinds of mucilage, however, will seldom answer as cements, as they will not sufficiently harden by drying, and they are more liable to mould, and to become brown and coloured during the requisite evaporation.

Lord Dundonald has given the following directions for preparing the mucilage from the lichen. This plant is the common large-leaved moss, that grows so abundantly on forest and fruit trees, and in the north of Europe and America, it grows to the length of a foot or more, giving a nutritious food to deer and other animals. The lichen has an outer skin, and below this a green resinous substance, and the remainder of the plant consists chiefly of gum and of fibrous matter on which water has no action. To separate the outer skin and the resinous matter, the plant must be scalded two or three times with boiling water, whereby the skin cracks, swells, and peels off. After this it is to be put into a boiler with about three quarts of water for every pound of the plant, and about half an ounce of potash or soda (which assists the extraction) and the boiling should be continued till the liquor acquires a considerable degree of gummy consistence. The liquor is then to be taken out and strained from the plant, and fresh water added to the same material, further to exhaust the gum. The several liquors, after standing some hours to settle, and then removing the dregs, are to be boiled down in a regulated heat to the consistence which is required for use, but not further, lest it should burn and become coloured. It requires two or even three boilings entirely to exhaust the lichen of its mucilage.

The method to be pursued in extracting the mucilage from other plants is so similar, that nothing more need be added on the subject. The substances the most likely to interfere with the purity of the gum, in those succulent plants that abound with mucilage, are for the most either insoluble in water or coagulable at a boiling heat; so that a judicious management of the boiling and clarification will generally succeed with those vegetables where the mucilage is in sufficient quantity to repay the trouble of extraction.

Another species of native mucilage, somewhat differing from any of the preceding, is gum tragacanth. This is a white opaque gum, in the form of twisted shreds, seldom free from visible impurities, and of a remarkably tough almost horny consistence, so that it cannot be reduced to fine powder without considerable labour. It exsudes from the stem and branches of a very thorny shrub (*Astragalus Tragacantha*, Linn) which grows on the island of Candia, and other parts of the Levant.

The juice dries in the sun, and being collected by the shepherds, is sent to Europe without any preparation. It differs from gum-arabic in being, properly speaking, hardly soluble in water, but when it is covered with water it swells prodigiously in the course of some hours, and absorbs so much of the fluid as to become soft and pulpy, but will not resolve itself into a liquid by any further addition of water. In this soft pulpy state it will readily mix with other mucilages, and may be spread thin over any surface, and it then dries into a very firm cement. It is employed much in bookbinding, mixed with paste, and is found to make a very strong cement.

MULE. See ANIMALS, *Domestic*.

MURIATIC ACID.—If a small retort or a proof bottle with a curved tube be half filled with well dried common salt, and some strong sulphuric acid be poured upon it, a copious effervescence takes place, and the elastic fluid thus extricated appears in the form of a white vapour as soon as it comes in contact with the atmosphere: when by the evolution of this gas all the common air has been driven out of the retort, the subsequent portions of gas may be collected in the usual manner in glass jars filled with mercury, and inverted in a bath of the same fluid. The air thus procured is known among chemists by the name of muriatic acid gas; it is transparent, colourless, and possessed of the same mechanical properties as common air and other elastic fluids. Its specific gravity, according to Fontana, is about = 0 00 09, but according to Kirwan, is = 0.00231, that of water being =1000.0, and of atmospheric air=0.00123. It has a peculiarly suffocating odour; to the taste is extremely sour and corrosive, and affects vegetable colours in the same manner as other acids. It is instantaneously fatal to animal life, and is incapable of supporting combustion; this peculiarity, however, belongs to it, that if a lighted taper is plunged into a jar full of it, the flame is considerably enlarged, and tinged of a greenish yellow colour before it is extinguished.

Muriatic acid gas is not, properly speaking, combustible, though it unites without difficulty with a considerable proportion of oxygen, forming oxymuriatic acid. The

affinity between water and muriatic acid is very powerful; even when this substance is in a gaseous state it holds a considerable quantity of water, from which it cannot be freed, otherwise than by the decomposition of this latter substance. If a little water be introduced into a jar of muriatic acid gas standing over mercury, an immediate absorption takes place, and the whole of the acid suddenly loses its gaseous state, heat being at the same time given out. A similar, though not so sudden an effect, is produced by charcoal, soft wood, sponge, and various other porous bodies, probably in consequence of their containing moisture. A piece of ice introduced into muriatic acid gas is melted as rapidly as if it was laid on a hot coal, in consequence of the liberation of caloric during the combination of the water and acid If alum, or any other salt containing much water of crystallization, be introduced into this acid gas, an absorption takes place, and the salt becomes pulverulent, in consequence of the transfer of the greatest part of its water to the acid. Iron filings, wax, phosphorus, sulphur, and other inflammable bodies, when brought into contact with muriatic acid gas, absorb more or less of it, and the residue, after washing with water, is inflammable; the cause of which will be explained presently, when we treat of the decomposition of this acid. Neither azot nor any of the simple or compound inflammable gases, have any action on muriatic acid; with ammoniacal gas, however, it combines instantaneously, the two airs, if rightly proportioned to each other, entirely disappearing, and solid muriat of ammonia is the result.

Although muriatic acid, when in the state of gas, is the purest form in which it is known, yet the inconvenience of keeping and applying any substance in this state being very great, it is always used, except on particular occasions, in a liquid form. Liquid muriatic acid, or spirit of salt, is prepared in the following manner. A capacious tubulated retort is filled about one-third of its capacity with decrepitated common salt (muriat of soda), and the juncture of the retort with the receiver is carefully closed with fat lute; to the receiver is adapted a Woulfe's apparatus, the bottles of which are placed in a frame or small cistern for the sake of keeping them cool by means of ice and water. The Woulfe bottles themselves are more than half filled with distilled water, and then concentrated sulphuric acid, in the proportion of about six ounces for every pound avoirdupois, is poured upon the salt through the tubulure of the retort, which is immediately after closed with its glass stopper. As soon as the acid and salt come into contact, the retort and receiver are filled with white vapour, and the disengagement of muriatic acid goes on for some time without the application of heat: when the current of gas through the Woulfe bottles begins to slacken, a pot of lighted charcoal should be placed under the retort, gradually increasing the fire till at a very low red heat no more gas is disengaged. What remains in the retort is now dry sulphat of soda, and the water in the Woulfe bottles will be found to be more or less impregnated with muriatic acid, according to the quantity of salt originally made use of. The method pursued in the manufacturing laboratories in England, is in general the same as that mentioned above, but with a greater simplicity of apparatus, and the vessel that performs the part of the retort, is either of earthenware or of iron; this last, however, is extremely improper, as a portion of iron always rises with the acid, and thus communicates to it that yellow straw colour which distinguishes common muriatic acid. In Germany, where sulphuric acid is dearer than it is in this country, the mode of manufacturing this acid is to mingle accurately one part of common salt with four of dried clay, and to subject the mass to strong ignition in iron or earthen vessels; at a high temperature the alkaline base of the salt combines with the earth, and the gaseous acid as it passes over is received into water where it is condensed in the usual way.

If a portion of water be confined in a jar over mercury, and muriatic acid gas be let up into it, a quantity of gas equal in weight to the water will be absorbed, while its bulk will be increased, according to Dr. Priestley, from 1 to 1.5, and according to Kirwan, from 1. to 1.33: hence the specific gravity of this liquid acid, according to the former, is = 1.33, and, according to the latter, = 1.5: but the specific gravity of the strongest muriatic acid that can be made and kept in the common method, does not exceed at 60° Fahr. 1.196. Pure liquid muriatic acid is as colourless as water; when exposed to the air it emits a white vapour; it affects the smell and taste in the same manner as the muriatic gas does: it combines with the alkalies and earths, forming neutral salts. Its action upon iron and zinc is very rapid, and accompanied by a copious disengagement of hydrogen gas; at a boiling temperature and in open vessels it oxydates and dissolves copper, tin, bismuth,

lead, cobalt, manganese, antimony, and arsenic; silver is also affected by it though very slightly; it seems to have no action whatever on gold, platina, mercury, tungsten, molybdena, tellurium and titanium. It dissolves all the metallic oxyds, and is an acid of remarkable activity. When heated for some time in closed glass tubes it corrodes them very sensibly, taking up the oxyd of lead from the white glass, and the alkali from green glass.

MURIAT OF SODA, or Common Salt.—Common salt is found in large masses, or in rocks under the earth, in England and elsewhere. In the solid form it is called *sal gem* or *rock salt*. If it be pure and transparent, it may be immediately used in the state in which it is found: but if it contain any impure earthy particles, it should be previously freed from them. In some countries it is found in incredible quantities, and dug up like metals from the bowels of the earth. In this manner has this salt been dug out of the celebrated salt mines near Bochnia and Wieliczka, in Poland, ever since the middle of the 13th century, consequently above these 500 years, in such amazing quantities, that sometimes there have been 20,000 tons ready for sale. In these mines, which are said to reach to the depth of several hundred fathoms, 500 men are constantly employed. The pure and transparent salt needs no other preparation than to be beaten to small pieces, or ground in a mill. But that which is more impure must be strained, purified, and boiled. That which is quite impure, and full of small stones, is sold under the name of rock salt, and is applied to ordinary uses; it may likewise be used for strengthening weak and poor brine springs.

Though the salt mines of Wieliczka, near Cracow in Poland, have long astonished the philosopher and traveller, yet it deserves to be remarked, that the quantity of rock salt obtained from the mines of Northwich is greatly superior to that obtained at Cracow. The bishop of Llandaff affirms, that a single pit, into which he descended, yielded at a medium 4000 tons of salt in a year, which alone is about two-thirds of that raised in the Polish mines. This rock salt is never used on our tables in its crude state, as the Polish rock salt is. See Salt-making.

MUST OF GRAPE. See Wine.

MUSTARD.—Mustard is a plant of which there are seventeen species, three of which are natives of Great Britain; the sinapis alba, nigra, and arvensis.

The alba, or white mustard, which is frequently cultivated as a salad herb for winter and spring use, produces white seeds, used for making the sauce called mustard.

The nigra, or common mustard, which is frequently found growing naturally, but is also cultivated in the fields for its brown seed.

The arvensis grows naturally on arable land in many parts of Great Britain. The seed of this is commonly sold under the title of Durham mustard-seed.

The white and brown mustard-seed is mostly imported from Holland, though always inferior to the English growth. Brown seed is higher in value than the white, and is chiefly used for pickling.

The manufacture of mustard flour is made by grinding the grain, and sifting it. It is an article of considerable consumption.

MUSTY CASKS. *Method of cleaning*, according to M. Lenormandes. From the *Annales des Arts et Manufactures.*

The author mentions, that he was taught the secret by a countryman.—He took, says he, "cow dung *very fresh*, and diluted it with warm water, so as to make it sufficiently liquid to pass readily through a large tunnel. He previously dissolved in this water 4 lbs. of common marine salt, and one pound of alum. The quantity of this liquid was equal to about a sixteenth part of the capacity of the cask. He put the whole in a pot, and heated it to ebullition, stirring it continually with a wooden spatula. He poured the hot liquor into the barrel, bunged it tight, and shook it five or six minutes every two hours, taking care, after every shaking, to pull out the bung, when a thick vapour, with a strong smell of must, issued from it. Twenty-four hours afterwards, he rinsed the barrel till the water came from it perfectly clear. During this operation, some water was heated, in which had been put two pounds of salt, and half a pound of alum, which he poured quite hot into the barrel; he shook it once, as in the former operation, and left the barrel well bunged. Two hours after, the water being still warm, he emptied it out, leaving the barrel to drain, and bunged it up very tight, till it should be wanted for use. A greater quantity of cow-dung, salt, and alum, than the above, will not injure the operation.—Cow-dung must be used, that of oxen is useless.

MYRTLE WAX.—This substance, obtained from the myrica cerifera, has, in part, the tenacity of bees-wax, without its unctuosity, and along with it, in some degree, the brittleness of resins. Its colour

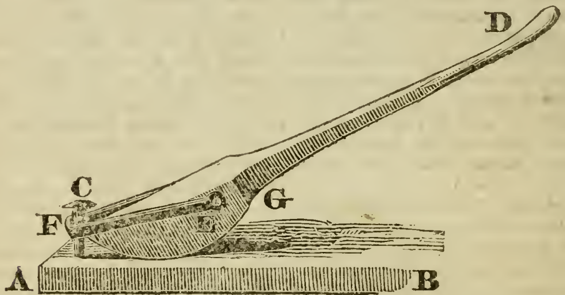
is a pale green. Specific gravity about 1.015. It melts at 109°; and at a temperature sufficiently high, burns with a peculiarly clear, white flame, producing little smoke, and emitting an agreeable aromatic smell. Water has no action upon it. About four-fifths of it are soluble in twenty times their weight of alcohol, at a boiling heat; but are deposited by cooling and standing a few days. Oil of turpentine softens it, and by the assistance of heat dissolves it. Caustic potash by boiling converts it into a soap. The mineral acids act upon it, though feebly. From all its habitudes Dr. Bostock infers, that it is a fixed vegetable oil, rendered concrete by the addition of oxigen.

N.

NAILS.—The manufacture of nails, forms a considerable part of American industry. It is not necessary to detail the manner in which they are made, nor to describe the apparatus usually employed for making them; both of which are well known. Several patents have been obtained for certain improvements either in casting, cutting, or otherwise making them, in a particular manner; and among these improvements, those of our countrymen rank the first. Nails may be either wrought, cut, or cast. The cut nail, however, is the most common. Mr. Finch obtained a patent for sundry improvements in this art, or trade, in 1790; Mr. Cufferd also in the same year; and Mr. Spencer in 1801, all from the British government. For information on this subject, accompanied with plates of the apparatus, the reader is referred to the volumes of the Repertory of Arts, especially the 7th, 9th, and 15th.

NAIL or BOLT DRAWER.—The following instrument was invented by Mr. Rich, of Great Britain, for the purpose of drawing nails or bolts; for which the Society for the encouragent of Arts, in 1787, granted him a premium of three guineas.

The following cut will exhibit the machine.



A, B, the piece of timber, in which the nail or spike C, intended to be drawn, is inserted.

D, E, the shape of the tool, consisting of a lever, D, that moves on a solid basis, in the form of a segment of a circle, as at E.

F, a square staple, turning on a centre, at G: and, if the spike to be drawn be held between the lever and the staple, any pressure at D will act with an effect proportionate to the distance *a* F, and D *a*; and the workman will thus be enabled to exert a very great force against the spike C.

NANKEEN DYE.—Besides the observations on the dyeing of a nankeen colour, given under the article Dyeing, and some account of the preparation under Iron, the following paper, by Mr. Brewer, we have extracted from the Transactions of the Dublin Society.

Process for Dyeing Nankeen Colour.

Mix as much sheep's dung in clear water as will make it appear of the colour of

grass, and dissolve in clear water one pound of the best white soap for every ten pounds of cotton-yarn, or in that proportion for a greater or lesser quantity.

Observe :—The tubs, boards, and poles, that are used in the following operations, must be made of deal; the boiling-pan of either iron or copper.

First Operation.

Pour the soap liquor prepared as above into the boiling-pan; strain the dung liquor through a sieve; add as much thereof to the soap liquor in the pan as will be sufficient to boil the yarn intended to be dyed for five hours. When the liquors are well mixed in the pan, enter the yarn, light the fire under the pan, and bring the liquor to boil in about two hours, observing to increase the heat regularly during that period. Continue it boiling for three hours, then take the yarn out of the pan, wash it, wring it, and hang it in a shed on poles to dry. When dry, take it into a stove or other room where there is a fire; let it hang there until it be thoroughly dry.

N. B. The cotton yarn, when in the shed, should not be exposed either to the rain or sun: if it is, it will be unequally coloured when dyed.

Second Operation.

In this operation use only one half of the soap that was used in the last, and as much dung liquor (strained as before directed) as will be sufficient to cover the cotton yarn, when in the pan, about two inches. When these liquors are well mixed in the pan, enter the yarn, light the fire, and bring the liquor to boil in about one hour; then take the yarn out, wring it without washing, and hang it to dry as in the former operation.

Third Operation.

This operation the same as the second in every respect.

Fourth Operation.

For every ten pounds of yarn make a clear ley from half a pound of pot or pearl ashes. Pour the ley into the boiling-pan, and add as much clear water as will be sufficient to boil the yarn for two hours; then enter the yarn, light the fire, and bring it to boil in about an hour. Continue it boiling about an hour, then take the yarn out, wash it very well in clear water, wring it, and hang it to dry as in former operations.

N. B. This operation is to cleanse the yarn from any oleaginous matter that may remain in it after boiling in the soap and dung liquors.

Fifth Operation.

To every gallon of iron liquor add half a pound of ruddle, or red chalk (the last the best) well pulverized.

Mix them well together, and let the liquor stand four hours, in order that the heavy particles may subside; then pour the clear liquor into the boiling pan, and bring it to such a degree of heat as a person can well bear his hand in it; divide the yarn into small parcels, about five hanks in each; soak each parcel or handful very well in the above liquor, wring it, and lay it down on a clean deal board. When all the yarn is handed through the liquor, the last handful must be taken up and soaked in the liquor a second time, and every other handful in succession till the whole is gone through; then lay the yarn down in a tub, wherein there must be put a sufficient quantity of ley made from pot or pearl ashes, as will cover it about six inches. Let it lie in this state about two hours, then hand it over in the ley, wring it, and lay it down on a clear board. If it does not appear sufficiently deep in colour, this operation must be repeated till it has acquired a sufficient degree of darkness of colour: this done, it must be hung to dry as in former operations.

N. B. Any degree of red or yellow hue may be given to the yarn by increasing or diminishing the quantity of ruddle or red chalk.

Sixth Operation.

For every ten pounds of yarn make a ley from half a pound of pot or pearl ashes; pour the clear ley into the boiling-pan; add a sufficient quantity of water thereto that will cover the yarn about four inches; light the fire, and enter the yarn, when the liquor is a little warm; observe to keep it constantly under the liquor for two hours; increase the heat regularly till it come to a scald; then take the yarn out, wash it, and hang it to dry as in former operations.

Seventh Operation.

Make a sour liquor of oil of vitriol and water; the degree of acidity may be a little less than the juice of lemons; lay the yarn in it for about an hour, then take it out, wash it very well and wring it; give it a second washing and wringing, and lay it on a board.

N. B. This operation is to dissolve the metallic particles, and remove the ferrugi-

nous matter that remains on the surface of the thread after the fifth operation.

Eighth Operation.

For every ten pounds of yarn dissolve one pound of best white soap in clear water, and add as much water to this liquor in your boiling-pan as will be sufficient to boil the yarn for two hours. When these liquors are well mixed, light the fire, enter the yarn, and bring the liquor to boil in about an hour. Continue it boiling slowly an hour; take it out, and wash it in clear water very well, and hang it to dry as in former operations: when dry it is ready for the weaver.

N. B. It appears to us, from experiments, that less than four operations in the preparation of the yarn will not be sufficient to cleanse the pores of the fibres of the cotton, and render the colour permanent.

NAPLES YELLOW. See Colour Making.

NAPTHA. See Bitumen.

NATRON. See Soda and Barilla.

NEALING. See Annealing.

NEEDLE. See Manufacture of Pins and Needles.

NEEDLE, *Magnetic*. See Magnetism.

NICARAGUA WOOD. See Dyeing.

NICKEL.—This is a metal of great hardness, of an uniform texture, and of a colour between silver and tin; very difficult to be purified, and always magnetical, whence it has been supposed to contain iron in its purest state. It even acquires polarity by the touch. It is malleable, both cold and redhot; and is scarcely more fusible than manganese. Its oxides, when pure, are reducible by a sufficient heat, without combustible matter; and it is little more tarnished by heating in contact with air, than platina, gold, and silver. Its specific gravity when cast is 8.279; when forged, 8 666.

We do not know that this metallic substance has been applied to any use; yet Fourcroy supposes it is employed in colouring porcelain or enamels.

Nickle is commonly obtained from its sulphuret, the kupfernickel of the Germans, in which it is generally mixed also with arsenic, iron, and cobalt. This is first roasted to drive off the sulphur and arsenic, then mixed with two parts of black flux, put into a crucible, covered with muriat of soda, and heated in a forge furnace. The metal thus obtained, which is still very impure, must be dissolved in dilute nitric acid, and then evaporated to dryness; and after this process has been repeated three or four times, the residuum must be dissolved in a solution of ammonia perfectly free from carbonic acid. Being again evaporated to dryness, it is now to be well mixed with 2 or 3 parts of black flux, and exposed to a violent heat in a crucible for half an hour or more.

According to Richter, the oxide is more easily reduced without any flux; and Thenard is of a similar opinion. Richter, however, says it is effected more speedily by moistening the oxide with a little oil. Thenard too advises, to pour oxigenized muriatic acid saturated with lime on the oxide of nickel, and shake them well together, before the ammonia is added; as thus the oxides of cobalt and iron, if present, will be so much saturated with oxigen, as to be insoluble in the ammonia, and consequently may be separated.

NITRIC ACID, Nitrous Acid, Aqua Fortis *of Commerce*.—This acid is found native, united with potash, and with several of the earths. It is also generated in several chemical processes, and may be produced by the direct union of its two constituent parts, *azot*, and *oxygen*, in sufficient quantity to afford satisfactory evidence of its chemical nature; but for the purposes of the laboratory and manufacture, it is always prepared from nitre, by the addition of some substance which has a stronger affinity with potash than the nitric acid has, assisted by distillation.

The most ancient way of procuring this acid, and which is still practised in many countries, is by heating strongly a mixture of nitre and clay, or nitre and green vitriol, in earthen or iron retorts, and receiving the acid vapour in proper vessels. It was soon found that alum and some other vitriolic salts answered the purpose as well as the vitriol of iron, and lastly the great improvement was made of employing the vitriolic acid alone, which is the method now universally adopted in the laboratory, and chiefly in manufacture in Great Britain, where this acid is generally cheap.

The way of procuring the nitrous acid in small quantities, is the following: take a plain glass retort of any size, put into it any quantity of dry purified nitre in powder (which need not be very fine) dropping it through a paper funnel, that none may lodge in the neck of the retort, and fill it not higher than at most two-thirds of the capacity of the body of the vessel, when the nitre lies light and uncompressed. Then pour in (through a glass funnel, with a stem reaching nearly to the bottom) concentrated sulphuric acid equal to about half of the weight of

the nitre, equally guarding against any lodgement of it in the neck of the retort. Then lute on a large tubulated glass receiver, and cement the joinings with *fat lute.* These two are all the vessels absolutely required, but the tube of the receiver must be only loosely stopped, or (what is a better way) it should dip into an empty bottle without luting the joinings. As, however, towards the end of the process, much acid vapour passes off which would be lost in the common way of proceeding, and is partially condensible by water, one or two bottles of the Woulfe's apparatus, half filled with water, may be added to the receiver, and the absorption tubes carefully placed, so that none of the acidulous water may be sucked back into the receiver, and mix with the stronger acid. The retort is then to be placed in a sand-bath, and the fire applied gradually.

As soon as the nitre and sulphuric acid mix, faint orange-yellow fumes arise, but very sparingly, till by the assistance of heat the nitre is completely dissolved in the acid. When this mixture begins to get hot, the fumes increase, and long wet streaks appear on the neck of the retort, which collect and fall down in drops in the receiver. The heat is now to be increased till the mixture boils, and at this point of gentle ebullition the materials are to be kept, during which the drops of acid fall in quick succession into the receiver, and the receiver itself is lined with the same streaks of acid drops. Towards the middle of the distillation, when both retort and receiver are filled with the acid vapour, the colour is only a faint orange, so that the materials within the retort can be seen without much difficulty by looking down (for the hot sand should be heaped up as high as possible, and above the level of the boiling fluid) and even if they cannot be conveniently seen, the process will be known to go on well by the gentle uniform hissing noise of the boiling materials, and the moderately rapid fall of condensed drops in the receiver, which last should be kept quite cold with wetted cloths on the outside, if necessary. During all this time little, if any, gas or vapour of any kind passes beyond the large receiver. At length the vapour in the retort becomes of a higher orange, which soon (and rather suddenly) deepens into a very dark, and nearly opake, orange-red, so that the materials can no longer be seen; and a little afterwards these begin to swell considerably, and to rise slowly up to the neck of the retort; and if this was at first more than half full, the hot half-fluid matter is apt to flow over into the neck, and thence into the receiver, unless the heat of the furnace be rapidly checked, and the top of the retort cooled by removing the upper part of the sand. The distillation is then to be continued with the heat kept up as high as possible without boiling over, and the whole receiver now becomes darkened with red-orange fumes, which find their way on to the connected bottles, where they are chiefly condensed in the water through which they are forced. At the same time, however, a considerable quantity of gas escapes; which, if examined, is found to be a mixture of azote with a very large proportion of oxygen. When nothing further is given out, and the heat is sufficient nearly to redden the bottom of the retort, the process is concluded.

The products of this distillation are:—a quantity of strong heavy nitrous acid, of a bright yellow colour, emitting copious orange-red fumes, of an excessively pungent and peculiar smell, and of the specific gravity of about 1.5, or half as heavy again as water, if the nitre was thoroughly dried before it was put into the retort, and the sulphuric acid was very concentrated. The quantity of this acid is on an average about half the weight of the nitre employed. Besides this the water that receives the nitrous vapour is converted into a weak acid liquor of a blue-green colour.

The substance remaining in the retort concretes into a beautifully white spongy saline mass, consisting of sulphat of potash with a small excess of sulphuric acid. This may be dissolved out of the retort by hot water, if the heat has not been so intense as to melt the glass and the salt into a kind of opake vitreous mass.

The proportions of nitre and vitriolic acid here given, are two of the former to one of the latter. Even a somewhat smaller quantity of vitriolic acid will disengage all the acid of the nitre, but the remaining sulphat of potash is harder, and the heat required for distillation is greater; so that if it be a preferable object to save the retort, not less than half the weight of sulphuric acid should be employed. If this is increased to two-thirds, which is sometimes done, the distillation is still easier, but the nitric acid contains some sulphuric acid, from which indeed it is seldom free till further rectified.

To prepare only a few ounces of the acid, a sand-heat is not necessary, but the retort may be heated by a lamp.

The nitrous acid thus prepared is very strong and fuming, and the least drop stains the hands yellow almost immedi-

ately. When heated to boiling, it gives out abundance of red nitrous vapour, and if kept boiling for a quarter or half an hour (which in a narrow-mouthed flask can be done without much loss of acid) it becomes when cold, limpid and colourless as water, and now no longer fumes. To preserve it colourless, it should be kept in a dark place, as the light gradually restores the colour.

Thus then there are two forms or species of this acid, viz. the orange-yellow fuming acid, and the pale limpid; and the former is more accurately termed in modern chemistry *nitrous* acid, and the latter *nitric*. The precise difference between the two will be presently noticed; but it may be here observed, that the nitrous appears to be the nitric holding a quantity of red nitrous vapour in solution.

Common nitrous acid contains, besides nitrous vapour, a quantity of muriatic and of sulphuric acid; the former arising from a small admixture of common salt, or more commonly of muriat of potash with the nitre; and the latter from the volatilization of part of the sulphuric acid added. It is of importance often, both in manufacture and in experiment, to get rid of these foreign acids, which may be done in the following way: the sulphuric acid is got rid of by re-distilling the acid upon about an eighth or tenth of pure nitre in a moderate heat, by which the sulphuric acid is detained; or else nitrat of lead may be added to the mixed acid, which will cause the sulphuric to separate in the form of an insoluble sulphat, after which the clear acid may be simply decanted off, or (what is much better) should be re-distilled.

To separate the muriatic acid, nitrat of silver may be dropped in gradually, till all the muriatic acid falls down as muriat of silver, after which the clear nitrous acid may be considered as pure, or, what is better, should be redistilled

The manufacture of this acid in the great way is now performed with equal simplicity in England, and with the same materials. The process is the following: rough nitre is first recrystallized, then the crystals are put (without pounding) into a large glass *body*, to which is added half the weight of sulphuric acid; a glass pipe is then luted to the body, and made to communicate with an empty receiver; and from this by three or four more pipes with other receivers half full of water, but in this case the pipes do not dip in the water. Heat is then applied, and the strong acid condenses in the empty receiver, whilst the acid vapour unites with the water of the others, forming the common aqua fortis. To purify the strong acid from the muriatic, the following simple method is found sufficient: a small quantity of distilled water is added to several pounds of the acid, which causes a great production of heat and a sudden gust of nitrous fumes, and in these fumes all the muriatic acid escapes, being more volatile than the nitric acid. By subsequent boiling, the rest of the nitrous vapour is got rid of, and the acid that remains is nearly pure nitric acid, of about 1.5 specific gravity. The residuary sulphat of potash is mostly sold to the alum-makers in Scotland.

The furnace and apparatus of an aqua fortis distiller consist chiefly of a long iron trough filled with sand, in which the retorts are buried in two rows, standing back to back, and under which is a long brick furnace to heat the sand. Each retort has its own receiver.—Sometimes, instead of glass retorts, very thick iron pots are substituted with advantage. These will last a very considerable time before they are so much worn as to be unserviceable.

Nitrous acid is also prepared in the large way in some countries by distilling nitre and clay, sometimes nitre and martial vitriol. The apparatus for both is the same, namely, large earthen pear-shaped pots, in which the materials are heated, and earthen globes for receivers. The pots are ranged in a long furnace in a double row, as already described. When clay is the material used, a harsh vitriolic clay is selected, which is first well dried in a small oven, then beaten to rough powder, and sifted. About five parts of nitre are taken to twelve of the clay, and, when well mixed, the mass is wetted either with water or with the weakest acidulous phlegm of former distillations. The mixture is then put into the pots, and the fire is kindled and kept up with those precautions which practice alone can teach, and the distillation continued till all the acid has come over, and the pots are nearly red hot. The acid procured in this way is generally pretty good, but must undoubtedly be much weaker than when made with sulphuric acid and nitre, since it is not uncommon to obtain nearly as much nitrous acid as the weight of nitre employed. Indeed it is obvious, that it must contain all the moisture originally left in the clay, as well as that employed in the mixture of the clay and nitre. The affinity that acts here in the production of the acid, must be that of the clay for the alkali of the nitre, when strongly heated. Besides this, the clays used are considerably vitriolic, which also assists

in the expulsion of the nitrous acid. The residue in the retort is a hard half-fused earthy mass, now turned to a deep red (owing to the complete oxydation of the iron of the clay) and consisting of all the earths of the clay, the alkali of the nitre, and a little sulphat of potash, which last must be separated by boiling water. This residue is called *cement earth of aqua fortis*, and is only used as a red earth in staining tiles, bricks, &c.

The process for making aqua fortis by martial vitriol (which is a very good method, and much used on the continent of Europe) is very simple. The vitriol is first calcined till it falls into a white powder, by which it loses nearly half its weight of mere water, but little or none of its acid. The calcined vitriol is then mixed with about its own weight of pure nitre, and the mixture is put, in some works, into earthen, in others into iron pots, to which glass receivers are well luted (but with a small vent-hole, for the uncondensible vapour to escape when opened) and the fire is gradually raised to redness, during which the acid distils over. In this as in other distillations of this acid, a fat lute made of clay and linseed oil is generally employed. The acid procured in this method is more ruddy and fuming than in any other, so as to be almost brown and opake, and in the process the receiver is often found starred with crystalline rays, which again melt down. These are probably sulphuric acid driven off by the violence of the heat, and saturated with nitrous vapour, which (as will be elsewhere mentioned) renders this acid crystallizable. The residue of this distillation is a mixture of sulphat of potash and red oxyd of iron, which is easily got out, unless the nitre was mixed with common salt, in which case it adheres very closely to the vessel The sulphat of potash is got out by lixiviation with hot water, and the insoluble residue is a perfect oxyd of iron, of a blood-red colour, called *colcothar*, and, when well washed and sifted, is much used by the looking-glass makers to polish their mirrors.

Other substances are occasionally used to disengage the nitrous acid from nitre, where they can be procured cheap. Sulphat of magnesia is very useful for this purpose, and in the neighbourhood of salt-works it may be sometimes obtained economically in sufficient quantity. In this case there appears to be first a double decomposition of the ingredients, by which sulphat of potash and nitrat of magnesia are produced, and then the heat drives the nitric acid off, so that the residue contains both sulphat of potash and uncombined magnesia. It is from very few other substances, however, that the nitric acid can be expelled by heat undecomposed, for when the nitrated alkalies and most other nitrated earths are heated, the acid is decomposed almost at first, and the products are, not nitric acid, but the elements of this acid disunited. Hence it is that nitre alone cannot be made to yield its acid by heat.

The distilling vessels are made either of glass, or earth, or iron. The former is undoubtedly the best material, but is expensive and liable to accidents. Iron retorts, when made very thick at bottom, last a considerable time, but the acid gradually acts upon them, and produces much red nitrous vapour, which causes the acid to be always excessively fuming and high-coloured. In some parts of Wirtemberg it appears that they have a way of lining the iron pots with an enamel glazing, which must unite all the advantages of iron and glass.

We shall now give the preparation of this acid according to the formula of the colleges. The Edinburgh college recommend two parts of nitre, and one of oil of vitriol, for distillation; the London, sixty ounces of nitre, and twenty-nine ounces of oil of vitriol; and the Dublin, six pounds of nitre, and three pounds of vitriolic acid. The specific gravity of the acid differs considerably: thus the Edinburgh college make it 1550 to 1000; the London and Dublin the same; but experiments make the concentrated acid much lower. The diluted nitrous acid of the colleges, which is made by mixing equal parts of nitrous acid and water, is the same as double aqua fortis of the shops. The single aqua fortis is about half the strength of the double.

The preparation of nitric acid, of the Edinburgh college, consists only in expelling the nitrous gas from the nitrous acid, as the nitrous differs from the nitric in holding nitrous gas in solution.

Richter's process for preparing colourless nitric acid, is said to be preferable. It consists in distilling a mixture of nitre, manganese, and sulphuric acid; in the proportion of 7lbs. of nitre, 2oz. of manganese, and about 4lbs. of the acid.

We do not conceive it of importance in this work, to notice the chemical composition, nor the properties, of this acid. Information of this kind may be found in scientific treatises on chemistry. Nitric acid, down to the common aqua fortis, is much used in the arts, particularly for etching on copper, and for dissolving tin as a mordant in dyeing.

NITRO-MURIATIC ACID. *Aqua Re-*

gia.—The term nitro-muriatic acid is not meant to designate any particular acid or modification of acid, but simply a mixture of nitric or nitrous and muriatic acid, or sometimes muriat of ammonia, which when united, produce a very important agent in many chemical operations. It is particularly as a solvent for gold that this combination (which is very ancient) has been known, and hence it was termed by the alchemists *aqua regia*, (gold being with them the *king* of metals) and is nearly the only substance that can dissolve this noble metal The composition of the aqua regia, fitted to dissolve gold, has been described under that metal. Platina also, like gold, is insoluble in either of these acids singly, but yields to a mixture of the two, though in different proportions. Antimony also is scarcely soluble in any acid but the nitro-muriatic, and the composition of the mixture the best fitted for this purpose, is still different from the others.

Dr. Priestley has found that a very powerful aqua regia, which dissolves gold with great rapidity, may be formed by impregnating liquid muriatic acid with the nitrous acid vapour. The proportion of constituent parts here widely differs from those of the common aqua regia for gold, which last is usually made by three-fourths of nitric, and one fourth of muriatic acid; whereas in making the other acid, the liquid muriatic acid hardly increases in bulk by saturation with the nitrous vapour. Dr. Priestley also tried to form a nitro-muriatic acid that would dissolve gold, by impregnating nitrous acid with muriatic acid gas, but without success, as the liquor would not touch this metal. As soon as the muriatic acid receives the nitrous vapour, it changes from a pale straw to a deep orange, much deeper than nitrous acid alone can be brought to.

Aqua regia is now made by a direct mixture of nitric and muriatic acids, as before observed, and generally in the proportions stated. It was formerly prepared by dissolving sal ammoniac, or common salt, in aquafortis.

NITRE. Salt petre. Nitrat of potash.—Nitre being an important article of commerce and manufacture, we shall dwell at some length on its formation and purification; and particularly on the means of obtaining it in the United States.

Nitre is a neutral salt, composed of nitric acid and potash in a state of perfect mutual saturation. Its primitive crystalline form is that of a rectangular octohedron, composed of two pyramids applied base to base, in such a manner that two opposite sides of the upper pyramid form with the corresponding sides of the lower one, angles of 120°, while the two other opposite sides form with their corresponding ones, angles of 111°. This figure, however, is of very rare occurrence. When the summits of the pyramids are deeply truncated, the result is a bevilled rectangular table, which is by no means unfrequent. But the most usual form which this salt assumes is that of the common quartz crystal, viz. a strait six sided prism, terminated at each extremity by a six-sided pyramid. The specific gravity of nitre, according to Newton, is = 1.9. It has a sharp, saline, and cooling though disagreeable taste. When fully crystallized it is very brittle, and the larger prismatic crystals, if held in the warm hand, will crack across with a very audible noise. It generally attracts a little moisture on exposure to the air, but this is probably to be attributed to the casual mixture of a small portion of deliquescent salt. With regard to the degree of solubility of nitre in water of different temperatures there exist some contradictions that require to be cleared up: according to Bergman, this salt is soluble in seven times its weight of water at the usual temperature, and in about its own weight of boiling water; from the experiments of Hassenfratz, however, it appears that a hot saturated solution of nitre, after being cooled down to 61° Fahr. and remaining at this temperature twenty-four hours, holds nearly one-fourth of its weight of salt, and at 54° Fahr. about one-sixth of its weight: according to Beaume, four ounces of boiling water will take up ten ounces of nitre, when the solution is made in a matrass; but if a bason, or any other open vessel is made use of, a pellicle begins to form at the surface of the liquor, when it contains water and salt in equal proportions. The following table of the specific gravity and composition of solutions of nitre in water, at 60° Fahr. has been constructed by Hassenfratz.

Sp. gr. of solution at 61° Fahr.	Proportion of Nitre in 100 parts of solution.
1.006	1
1.012	2
1.018	3
1.024	4
1.030	5
1.035	6
1.040	7
1.046	8
1.053	9
1.059	10
1.065	11
1.072	12
1.078	13
1.085	14

Sp. gr. of solution at 61° Fahr.	Proportion of Nitre in 100 parts of solution.
1.091	15
1.098	16
1.105	17
1.111	18
1.118	19
1.125	20
1.132	21
1.138	22
1.145	23
1.152	24
1.158	25

If a saturated solution of nitre is boiled strongly, and more especially if the boiling temperature is raised by the addition of any deliquescent salt, a very notable proportion of the nitre is volatilized with the water.

Nitre is readily fusible at a heat almost equal to that of melting zinc, and may be kept for a considerable time at this temperature, without undergoing any change, except a slight loss of weight from parting with its water of crystallization; a piece of charcoal may even be immersed in it without producing any detonation. When poured out on any flat surface, it presently congeals into a white translucent mass, commonly known by the name of *crystal mineral*.

The following is the composition of this salt and the proportions, according to Bergman.

49	Potash
33	Nitric acid
18	Water
100	

According to Wenzel, 100 parts of nitre contain

48.13	Potash
51.87	Acid and water
100.00	

But, according to Kirwan, 100 parts of crystallized nitre, dried at 70° Fahr. are composed of

51.8	Potash
44	Acid
4.2	Water
100.0	

and this estimate being incidentally confirmed by other experiments of Berthollet and of Keir, is probably very near the truth.

The uses of nitre are very important. It is employed in prodigious quantities in the manufacture of gunpowder, and in all kinds of pyrotechnical compositions. It is the only salt from which nitric acid is habitually made, both in the large and small way; it is also largely consumed in the preparation of sulphuric acid from the combustion of sulphur. When mixed with common salt, it adds to the efficacy of the latter in preserving animal flesh from decay; it is employed by the glassmaker and the goldsmith, and is in constant use in the laboratory.

We now proceed to treat of the natural history and manufacture of nitre, as carried on in various countries, but chiefly in France, where its production has been more an object of philosophical investigation than in any other country.

Nitre may be considered both as a natural and artificial product. Native nitre, mineralogically speaking, is a substance of very recent formation. It appears to occur in two different repositories: the first of these is limestone, and the second vegetable soil. The calcareous repository is either a peculiar variety of secondary floetz limestone, or calcareous tufa, or chalk, or indurated marl. In these rocks it occurs as a thin granular crust, or an efflorescence of minute spicular crystals, overspreading the outside, and particularly lining the inside of the caverns, both natural and artificial, with which these rocks abound. Hence probably is derived its ancient name saltpetre (*Sal petræ*, rock salt). Calcareous strata, containing nitre, are found in various parts of South America, in some districts of France, in the county of Bamberg, and at Hamburg near Wurtzburg. But the most celebrated repository of native nitre is the Pulo of Molfetta, in the province of Puglia, in the kingdom of Naples. The Pulo is a deep cavity, in the form of an inverted cone, produced by the falling in of several large natural caverns, and communicating laterally with other caverns, both natural and artificial, that yet remain entire. All the strata in which these excavations occur, are of hard secondary limestone, abounding with the remains of organized bodies. The whole of these caves, at the time the Abbe Fortis called the public attention to them, were lined with an efflorescent crust of nitre, more than an inch in thickness, which after being scraped off, was again renewed in the course of a few days in constant succession. Thin fragments of stone were often falling down, being forced from their place by the crystallizations of nitre beneath them; the substance of the rock also, to the depth of a foot or more from the surface, was richly impregnated with the salt, which might be separated by lixiviation; but specimens taken from a greater depth, seem to contain no nitre ready formed, at least boil-

ing water was incapable of dissolving out any. It appears, however, from the testimony of Dolomieu, that a piece of this rock after lying for two months in a dry cabinet, became covered with a thin crust of nitre. Specimens of the nitrous crust from the Pulo have been analysed both by Klaproth and Pelletier, and the results agree full as well as can be expected in the examination of a substance so liable to slight variations in its composition.

Klapr.		Pelletier.	
425.5	—	407.5	Nitre
2.	—	——	Muriated potash
		26.7	Muriats
		20.8	Sulphats, soluble in cold water
254.5	—	96.7	Sulphat of lime
304.	—	410.	Carbonat of lime
986.0	—	961.7	
14.	—	38.3	Loss
1000.	—	1000.	

The second repository of native nitre is vegetable soil. It is asserted by some chemists, especially those who maintain that nitre is a product of vegetation, that all soils contain nitre in proportion to their fertility: Mr. Beaume lixiviated carefully 36 specimens of fertile soil, and did not obtain a particle of nitre from any one of them. There is no country in Europe, the soil of which is so rich in this salt as Spain. It is asserted by Bowles, that nearly a third of the uncultivated lands in the eastern and southern provinces of this kingdom, afford it in abundance under the following simple management. The land is ploughed twice or thrice during the winter and spring, to the depth of three or four inches; it lies fallow the whole summer, and about the middle of the autumn, the soil having been thus exposed to the full action of the air, is carted off and lixiviated: the liquor is then boiled down in the usual manner, and affords, by cooling, a quantity of nitre mixed with from 20 to 40 *per cent.* of common salt.

A considerable part of the soil in Lower Hungary is richly impregnated with nitre, and several of the wells and springs are incapable of being used as drink on account of their containing from two-thirds to four *per cent.* of this salt.

Many of the lands in India, especially in the vallies of the great rivers, are exceedingly abundant in nitre. In the presidency of Calcutta alone between 7 and 8000 tons are annually manufactured. Sometimes it covers the surface of the soil with a saline efflorescence, which being swept off, is renewed every other day at particular seasons of the year. The soil of those lands in which it is less abundant is raked up into small heaps, and mixed with the scrapings of roads and cattle stalls, and after being exposed for a certain time to the action of the air, is lixiviated: the earthy residue is mixed with fresh earth, and after two years affords as large a produce of nitre as at first.

In many nitrous soils the acid which they contain is combined, for the most part, with lime instead of potash, so that the produce of real nitre which they afford by the usual mode of treatment is very small: long experience, however, has taught the nitre-makers in every country where these soils occur, to remedy this defect by the addition of wood-ashes. The rationale of this, though wholly unknown to the greater number of those who practise it, is sufficiently obvious to the chemist; the carbonated alkali of the ashes, and the calcareous nitrat of the soil, mutually decompose each other, and carbonated lime and nitrated potash is the result. Many of the nitrous soils in India require this alkaline addition, as well as those of China, and other parts of Asia. Much of the nitrous soil in the Crimea and Ukraine also is of this description: in appearance it resembles common black vegetable mould, except that it is more unctuous to the touch, and is so light and of such little coherence, as to be converted to a loose dust by a few days of dry weather. Those parts of the Crimea that have been long uncultivated, and especially the artificial mounds that have served for burial places, and the scites of towns, are selected by the nitre-makers. The soil being dug up, is mixed with about one-fifth by measure of wood-ashes, and lixiviated, in perforated casks, in the usual way: the liquor thus produced, when concentrated by repeated lixiviations, is mixed with the mother water of a preceding crystallization, and boiled down for 24 hours, removing from time to time the common salt and muriated potash that separates during the process; it is now transferred, while hot, into shallow coolers, in order to crystallize, which it does in 24 hours more. The rough crystals being drained, are again dissolved in water, and the product of the second crystallization is a nitre somewhat impure, but yet in a fit state for the market. Four hundred cubic feet of the mixture of earth and wood-ashes, afford 42 lbs of nitre of the first crystallization, which by the subsequent refining is reduced to 39 lbs.

Dr. Brown in the Trans. Phil. Soc. vol. vi, speaking of a nitre cave in Crooked creek, in Kentucky, observes that "the quality of the nitre procured from the earth in calcareous caverns, is universally believed to be different from that which is found in the sand rocks. I have not been able to ascertain, with any degree of precision, the quantity annually manufactured in this state, nor the number of caverns which are known to contain it. I have, however, visited several of the most remarkable of them, and from the best information I could procure, I have formed the following estimate:

	lbs. of Nitre.
The great cave on Crooked creek, a branch of Rock castle, supposed to contain	1000000
Scott's cave, two miles distant from the great cave . . .	200000
Davis's cave, six miles distant from the great cave	50000
Two other caves, within a mile of the great cave	20000
A cave on Rough creek, a branch of Green river	10000

Besides these, which I have had an opportunity of examining, I have heard of many others in various parts of the state: some of which are esteemed very rich in nitre, and are said to be of great extent.

The great cave on Crooked creek, in Madison county, is situated about sixty miles south-east of Lexington. It has two mouths, which are 646 yards distant from each other, and about 150 yards from a large creek, which winds round the hill through which the cave affords a commodious passage for horses and waggons. The general level of the floor of the cave is 80 feet above the creek. The average height of the arch is ten feet, though in many places it rises to fifty or sixty. The breadth of the passage is generally about forty feet, in some parts it is seventy or eighty feet. The floor has the appearance of a large public road, which has been much frequented. The ceiling is, in most places, smooth, with but few incrustations or stalactites. In some of the chambers, however, there are appearances of Gothic rudeness and irregularity, which are truly sublime. When these vast chambers are sufficiently illuminated by the torches and lamps of the workmen, they present scenes so uncommon and so romantic, that the most stupid beholder cannot contemplate them without expressions of the greatest astonishment. During the winter season, the effect of these scenes is greatly increased by a stream of water, which, issuing from a small opening in the arch of the cave, about twenty feet above the floor, and falling into a basin, occasions a noise which, in these calm regions, can be heard at a great distance, and echoing from arch to arch, fills the mind with the idea of some mighty cataract.

The temperature of this cave, during the last winter, (the coldest we have had for several years) was generally 52° Fah. Sometimes the mercury rose as high as 57°, but never sunk to the freezing point, when the thermometer was placed at any considerable distance within the cave. In one chamber, however, the heat was frequently so great as to be disagreeable. About sixty paces from the south entrance, a passage leading from the main avenue conducts you to this chamber, which is nearly circular, and about twenty feet in diameter. The arch over this part of the main avenue, and that over the passage leading to the warm chamber, are equally elevated; but the ceiling of the chamber is twenty or thirty feet higher. As you approach the chamber, the floor gradually rises until it ascends above the level of the arch of the passage. As soon as you ascend above that level, you perceive the air uncommonly warm, even when the temperature of the passage is near the freezing point. The air which fills the main avenue in summer and autumn is forced into this chamber, whenever the external atmospheric air becomes so much condensed by cold as to rush into the mouth of the cave; and whenever, during the winter, any portion of air in the main avenue, where the passage leads off, is accidentally heated by fires, or by carrying torches or lamps through the cave, as this heated air cannot escape by the mouth of the cave (for the arch descends towards the mouth) it ascends into this chamber, and rises to the ceiling, where it must remain until the external air, and that in the passage and avenue, acquire a higher temperature than the air in the chamber. This chamber then is constructed precisely upon the principles of the Russian vapour-bath, so minutely described by count Rumford.

During the winter season, the walls and floor of this cave remain perfectly dry; but in summer innumerable drops of water collect upon the rocks, and trickle down upon the floor, which sometimes becomes as moist as a bed of mortar. This is particularly the case, during very hot weather, when the atmosphere is loaded with vapours. I collected a quantity of the liquid condensed upon the rocks, and found that it possessed the same properties with the liquor obtained by lixi-

viating the earth on the floor of the cave. It would appear from this fact, that the nitric acid is formed in the cave, and is condensed upon the rocks, the lime of which it dissolves. But in what manner this nitric acid is formed, I confess myself wholly ignorant, as there are no substances in a state of putrefaction, within the cave, which could yield the requisite supply of nitrogene gas. It is to be remarked, that the whole of the water condensed upon the rocks, does not taste of the nitrate of lime. A great part of it is quite insipid, although dropping upon earth which is rich in nitre; and many parts of the cavern have been found so completely filled with clay, that it is not easy to conjecture how it was possible for atmospheric air to reach them; and this clay too is strongly impregnated with nitrate of lime. The depth of the earth on the floor of this cave has never yet been ascertained. In some places the workmen have dug down fifteen feet, and the earth, even at that depth, still contains nitre. It is commonly supposed that, throughout the cave, every bushel of earth contains at least one pound of nitre. In many places it will yield more than two pounds to the bushel. Formerly the earth was taken out of the cave and lixiviated near the stream; at present hoppers are erected in the cave, and the earth, after lixiviation, is left to be impregnated again with nitrat of lime; but what length of time will be requisite to saturate it, has not yet been ascertained.

The workmen have different modes of forming an opinion with regard to the quantity of nitre with which the earth may be impregnated. They generally trust to their taste; but it is always considered as a proof of the presence of nitre, when the impression made on the dust by the hand or foot, is in a very short time effaced. Where the nitre is very abundant, the impression made to-day will be scarcely visible to-morrow. Where there is a great deal of sand mixed with the dust, it is commonly believed that a small quantity of potash will suffice for the saturation of the acid.

The method of making saltpetre, usually practised in Kentucky, is as follows:

The earth is dug and carried to hoppers of a very simple construction, which contain about fifty bushels, cold water is poured on it from time to time, and in a day or two a soluion of the salts runs into troughs placed beneath the hoppers. The lixiviation is continued as long as any strength remains in the earth. The liquor is then put into iron kettles, and heated to ebullition; it is afterwards thrown upon a hopper containing wood-ashes, through which it is suffered to filtrate. As the alkaline part of the ashes is discharged before the nitrate passes through, the first runnings of this hopper are thrown back; and after some time, the clear solution of nitrate of potash runs out, mixed with a white curd, which settles at the bottom of the trough. This clear liquor is boiled to the point of crystallization, then settled for a short time, and put into troughs to crystallize, where it remains twenty-four hours; the crystals are then taken out, and the mother-water thrown upon the ash-hopper, with the next running of the nitrate of lime. When the quantity of the nitrate of lime is too great for the portion of ashes employed, the workmen say their saltpetre is in the "*grease*," and that they do not obtain a due quantity of nitre. If there has been too great a proportion of ashes employed, they say it is in the "*ley*," and when it is left to settle previous to crystallization, a large quantity of salt will be deposited in the settling troughs, which they call "*cubic salts*." These salts are again thrown upon the ash-hoppers, and are supposed to assist in precipitating the lime from the nitrate of lime, and, in the opinion of the workmen, are changed into pure saltpetre. They consider this salt as nitre *killed*, as they express it, by the excessive strength of the ley. To make 100 pounds of good saltpetre at the great cave, eighteen bushels of oak ashes are necessary; ten of elm, or two of ashes made by burning the dry wood in hollow trees. In the discovery of the value of this latter kind of ashes, the philosophers and chemists of Europe have been anticipated by the saltpetre-makers of Kentucky. The earth in some caves does not require half this quantity of ashes to precipitate the impure salts.

When wood-ashes cannot be readily obtained near the caves, the liquor which runs from the earth in the hoppers is boiled down to the point of crystallization, and suffered to become solid by cooling. In this form, which is called "*thick stuff*," it is transported to a part of the country where ashes can be procured, dissolved in ley sufficiently strong to precipitate the lime, settled in troughs, and then boiled down and crystallized. This thick stuff is extremely liable to deliquesce in warm moist weather, and is therefore commonly melted down, and put into casks before it is carried from the caves. Horned cattle are very fond of it, and a small portion of it is almost instantly fatal to them. Those who have had frequent opportunities of seeing cattle perish in this way, remark that the blood, when

drawn from their veins, is of a very black colour, and flows with great difficulty. A substance possessing such active properties, might deserve the attention of experimental physicians, and may possibly merit a share of that praise which has been so liberally, and perhaps so injudiciously, bestowed upon the nitrate of potash.

After these observations on the calcareous nitre-beds in Kentucky, and the modes commonly employed for obtaining that salt, I shall mention some of the most remarkable circumstances which have come to my knowledge, relative to the rock ore, or sand rocks, which yield nitre supposed to possess peculiar qualities.

These sand rocks are generally situated at the head of a ravine or narrow valley, leading up a steep hill or mountain: ascending the streamlets which run through these valleys, the banks close in upon you and become perpendicular. The rocks are frequently from sixty to one hundred feet in height, and jutting over their bases, which rest on a calcareous stratum, often forming a shelter large enough to secure a thousand men from the inclemencies of the weather. During the winter season a small rill is precipitated from the top of these rocks, and in summer, water generally issues from between the silicious and calcareous strata. These sand rocks, which probably once formed a complete upper stratum, have been for ages exposed to the destructive operations of rains and frosts, and as they crumble off, are carried by torrents into the plains and rivers beneath. The summits of all the hills in the vicinity of Rock-castle, Licking and Sandy, are still covered by masses of these rocks, which, from their beauty and variety of figure, might, at a small distance, be mistaken for the ruins of Gothic cathedrals, or baronial castles. Vast blocks of them have rolled down into the vallies, at a period of time so remote that they are now covered by trees of a luxuriant growth. These rocks, when broken perpendicularly, present a surface consisting of strata so irregular, with regard to their position, and so different in colour, and in the size of the particles of sand, that it is impossible to doubt of their Neptunian origin. The minute inspection of them never fails of awakening in the mind the recollection of the shore of some vast lake, where the rage of the winds and the waves has piled up hills of sand, which time consolidates into rock.

Several years ago the saltpetre-makers discovered that the sand and rubbish, sheltered from rains by these rocks, contained a rich impregnation of nitre, and that only a small portion of ashes was necessary for its purification. They soon after found, that the sand rock itself tasted strongly of saltpetre, and immediately commenced the new method of working.

After blowing off large blocks of the rock, they break them into small pieces with hammers, and throw them into kettles containing boiling water: as soon as the rock falls into sand by the action of the hot water upon it, they put it into hoppers and wash out all the nitre by frequent additions of cold water; this solution is boiled down and crystallized without any mixture of ashes or potash. Sometimes, when the mother-water has been very often added to fresh solutions of the nitre, they find it necessary to use a very small quantity of ashes.

I have been informed by Mr. Fowler, that he and his associates have made saltpetre at twenty-eight different rock-houses or caverns, from which they have obtained about 100,000 lbs of nitre; all these are situated on the north side of Kentucky river, within seventy miles of Lexington. He remarks that he has never seen a rock facing the north or west, which was very rich in nitre. He has always desisted from working a rock when it failed to yield him ten pounds to the bushel of sand. He has often obtained twenty or thirty pounds per bushel. He assured me that he once discovered a mass of very pure nitre, which was found to weigh 1600 pounds. Mr. Foley, another saltpetre-maker, found one containing 100 pounds: another mass was found on Rock-castle, which report says weighed 500 pounds. I have now in my possession a solid mass of native nitrat of potash of singular purity, which weighs three pounds; it is more than four inches in thickness, and is only a small portion of a block of nitre found last summer on Licking river: I have likewise a number of smaller specimens, which I, myself, procured from the different caves which I visited some weeks ago. These are generally found between the rocks which have fallen from the cliff, or the crevices of those rocks which still remain in their primitive situation. The rocks which contain the greatest quantity of nitre are extremely difficult to bore, and are generally tinged with a brownish or yellow ochre colour. Sometimes they contain an oxyde like manganese, and sometimes great quantities of iron ore, which resembles the bark of the scaly-bark hickory, surrounded by a finely powdered brown oxide. At some of these rock-houses three hands can make one hundred pounds of good nitre daily; but forty pounds may be considered as the average product of the

labour of three men at those works which I had an opportunity of visiting.

The workmen being badly provided with tools and apparatus, desert a rock whenever its size or hardness renders it difficult for them to manage it, and go in quest of a new establishment. Several caves and rocks which these strolling chemists have deserted, still contain many thousand pounds of nitre. These men are continually searching for masses of pure nitre, or rich veins of ore, by which much of their time is unprofitably dissipated. Still, however, most of our saltpetre-makers find it their interest to work the sand rock rather than the calcareous caverns, which last yields a mixture of nitrate of potash and nitrate of lime. The rock salpetre is greatly preferred by our merchants and powder-makers, and commands a higher price."

In the paper on the manufactures of the United States, the following fact, as it respects the quantity of nitre made in this country, appears, viz. Virginia prepares annually 59,175 lbs.; Kentucky, 201,937; Massachusetts, 23,600; East Tennesee, 17,531; West Tennesee, 144,895; making nearly half a million pounds of home-made nitre, as good as that brought from foreign parts.

Before the general use of gunpowder in war, the produce of native nitre was abundantly sufficient to supply the European demand for this article; but when, in consequence of the universal adoption of fire-arms, the consumption of this salt was prodigiously increased, it became an important object for every nation, and especially those that were the least commercial, to encourage by every method the domestic manufacture of nitre. Every kind of soil that had the least resemblance to the nitre soils of Spain and India, was examined by lixiviation, and by degrees it was ascertained that the surface soil of farm-yards, of cattle-stalls, of cellars, of privies, and other places long exposed to the vapours of putrefying animal matter, afforded, when mixed with wood-ashes and lixiviated, a considerable quantity of nitre. It was also discovered that the plaister, mortar, and what is included under the general term brick-rubbish of old houses, was capable of yielding this salt by a similar experiment. In consequence of this discovery, all these substances were claimed by the crown in most of the countries of Europe, and granted to societies of saltpetre-makers, incorporated for the purpose of supplying the public magazines of the country with this indispensable commodity. England and Holland were soon able to supply themselves at an easy rate with nitre, by means of their commercial connexions with India and China, and therefore attended only a very short time to the domestic preparation of this salt. France, Germany, and the northern states of Europe, on the other hand, importing but a small quantity of nitre in proportion to their wants, have always encouraged its manufacture by every method in their power. In the former of these countries, especially, the privileges of the saltpetre-makers were so extensive and so rigorously enforced, as to occasion much petty tyranny and vexation, besides operating as a direct discouragement to agriculture. These manufacturing companies were allowed to take away without compensation all the nitrous soils that they could discover: hence when a house was pulled down, such part of the old materials and old foundation soil as suited their purpose was selected from the rest, and carried off by them: they had also the right of digging up once a year the earthen floors of every out-house, and in some provinces even of the inhabited cottages: the farmer's yards were subject to the like troublesome visitations, by which he was deprived of a considerable quantity of his best manure; and every parish or district was obliged besides to furnish a certain amount of wood-ashes. These terrible means of annoyance were placed by the crown in the hands of the farmers general, and by them were intrusted to inferior agents, more disposed to exercise them so as to obtain from those in their power a pecuniary composition, than to exert their privileges for the public advantage; the consequence of which was, that, notwithstanding the trouble and extortion by which individuals were thus severely harassed, the annual produce of nitre, at the accession of Turgot to the ministry, scarcely exceeded one half of what it had amounted to half a century before. An important reform, however, was introduced by this able statesman: the privilege of digging up the floors and cellars of inhabited houses was abolished, the requisitions of fuel and wood-ashes were restrained, and the administration of this department was taken from the farmers general, and intrusted to a particular commission, of which Lavoisier and Clouet were leading members; a considerable sum of money was placed at the disposal of the Royal Academy of Sciences, to be distributed as prizes by this body to the authors of the best memoirs on the preparation of saltpetre; in consequence of which various important changes took place in the management

and construction of artificial nitre-beds, and the refining of their produce. By these means the yearly amount of nitre made in France was increased during the period from 1775 to 1785, from 1,800,000 lbs. to 3,500,000 lbs. Four years after this period the revolution war commenced, for the supply of which a prodigious quantity of gunpowder was demanded, while all the requisite nitre was obliged to be drawn from domestic supplies. To meet this exigency, the knowledge and personal superintendance of the ablest chemists of Paris was directed to this important object, and in the space of a very few years, the produce of nitre was more than quadrupled, and a simplicity and expedition introduced into the refineries of this salt, that seem to have brought its manufacture nearly to perfection.

In our account of nitric acid we have shown that the component parts of this substance are azote and oxygen; animal matters in general contain a large quantity of azote combined in various proportions with hydrogen, carbon, and other substances. When the decomposition of animal matter by means of the putrefactive fermentation takes place, its elements enter into new combinations with each other, and for the most part assume the gaseous form. Now although azote, like several other bodies, when it has completely acquired the state of elastic fluidity, is but little disposed to combine with oxygen at the usual atmospheric temperature, yet, when in its nascent state, and particularly when mixed at the same time with easily combustible substances, it unites with oxygen without much difficulty. Hence it is obvious how nitrous acid, or more probably nitrous vapour, is produced by the contact of atmospheric air and putrid gas. But the acid is produced slowly, and in proportion as it forms will fly off together with the other volatile ingredients, except it meets with an alkaline base to combine with into a neutral salt. It might seem, *a priori*, a matter of perfect indifference, as far as the mere formation and detention of nitrous acid is concerned, whether one alkaline substance or another was employed for this purpose; but experiment has shown, as we shall detail more at large presently, that the proper fixed alkalies, whether in a mild or caustic state, are by no means so efficacious as carbonat of lime. Thus it appears that three conditions are requisite for the production of nitrated lime (from which by the subsequent addition of carbonated potash common nitre is readily obtained) viz. animal matter in a state of decomposition, atmospheric air, or rather the oxygenous part of it, and carbonated lime.

The first proposal for the construction of artificial nitre beds came from Glauber. This able chemist, reflecting on the circumstance, that earth which had been long exposed to exhalations from the dung and urine of sheep and other animals, or in which animal bodies had been buried, was capable of affording nitre by lixiviation, concluded that this salt was contained in animal matter: but finding that various animal fluids, such as urine and blood, afforded no nitre when recent, he was induced to try the effect of putrefaction on them: for this purpose he filled an open vessel with blood, and exposed it to spontaneous decomposition till nothing remained of it but a loose earth: from this by lixiviation he obtained a portion of nitre; hence he concludes that the salts contained in recent animal matter are in an inert, or, as he calls it, a dead state, till by long exposure to the air and fermentation they acquire from it a vital spirit. From the nitrous efflorescences on the plaister of cellar walls, he inferred that the saline base of nitre was also contained in certain earths; and because that part of the plaister in immediate contact with the bricks, and therefore excluded from the air, afforded no nitre by lixiviation, he drew the same conclusion as in the former case respecting the *vivifying* influence of the air in the formation of nitre. It being a matter of common notoriety that earth, when long impregnated with the lees of wine, became rich in nitre, this circumstance, together with other collateral arguments, induced him to infer the presence of nitre in vegetables also. In pursuance of this theory, he proposes the following plan for the formation of nitre. Let a large square wooden vat be made open at top, and with a perforated false bottom placed a few inches above the real bottom, and between the two bottoms let a pipe with a stop cock be inserted so as to discharge any liquor into a shallow open reservoir sunk into the ground just in the front of the vat: on the opposite side of the reservoir let another vat similar to that already described be placed; and, to complete the apparatus, let a pump be fixed in the reservoir by which its contents may be transferred to either of the vats that the workman chooses. Every thing being complete, let the vats be filled with horses', cows', or sheep's dung mixed with leaves or any dry vegetables: then draw a weak alkaline ley from quicklime and woodashes, and pour it into one of the vats till it stands a finger's breadth above the other

ingredients. In about 12 hours time turn the cock, and let the liquor drain into the reservoir, whence it is to be pumped again into the other vat, and after 12 hours more returned into the reservoir. In the space of a few days the contents of the vats will heat and ferment strongly: no further care is required till the decline of the fermentation, which may be known by the cessation of the steam: the materials are then to be again drenched with the liquor in the reservoir for 12 hours, and when this is again discharged the fermentation will recommence. This method being pursued for ten or twelve months, (taking care to keep the vats filled with fresh portions of leaves and dung as the mass subsides) both the liquor and the contents of the vats will be found to be very rich in nitre.

The above method of Glauber's deserves notice as the first attempt at the artificial manufacture of nitre, although there is little doubt that its success is greatly exaggerated, as is but too much the custom of this author. Another method proposed by the same chemist, and the success of which is better authenticated, is the following. Construct a vault of frame work of any dimensions, and line it to the thickness of three or four inches with plaister composed of the following materials, viz. one part of quicklime, one of woodashes, and two of cow's or horse's dung, with a sufficient quantity of urine to work it up to a proper consistence. This plaister being carefully applied, is to be dried by a gentle fire to be made under the vault, a second coating of the same materials is then to be put on, and thus, by alternate drying and plaistering, the vault is to be made two or three feet thick Being now sufficiently strong, the wooden framing may be removed. The plaister, in proportion as it dries, is to be restored to a proper state of moisture by the application of urine; and, in the space of a few months, more or less according to the warmth of the air and other circumstances, the whole inside of the vault will be covered with nitrous efflorescences: by degrees the plaister will be impregnated with nitre through its whole substance, at which time the vault being broken down, and its materials being duly lixiviated, a large quantity of nitre will be obtained. This method was adopted in many parts of Germany with reasonable success; but, requiring much manual labour, was at length abandoned for more economical processes.

In direct opposition to the instructions on this subject by Glauber, who had clearly shown the absolute necessity of the presence of air to the formation of nitre, several very large experiments were made, chiefly in Sweden and Germany, to prepare this salt by filling large trenches with animal and vegetable refuse of various kinds mixed with quicklime and woodashes, and duly watered with urine. But, though all other circumstances were tolerably favourable, the exclusion of air from the greater part of the mass so delayed the production of nitre, that after the expiration of 20 years a smaller quantity of this salt was thus obtained than is yielded by the same materials in two or three years when the air is freely admitted to them. Attempts were made to remedy these defects by the insertion of pipes and air shafts, but with little success compared to the trouble and expense; so that at length, instructed by experience, the Swedes adopted that mode, which, with a few modifications, they still retain, and the advantages of which are daily more and more apparent. Upon a square floor of brick or stone, is laid a bed, a few inches thick, composed of woodashes, lime, and mellow vegetable earth moistened with urine, and the mother water obtained in the refining of nitre: upon this is placed a layer of straw or old thatch, then another of the composition, and so on alternately till a pyramid 8 or 9 feet high is constructed. In order to preserve these piles from the rain and snow, which would wash out the salt as fast as it formed, a number of stout poles are stuck in the ground all round the floor, the tops of which are tied together, and their interstices carefully closed with intertwisted twigs, thus excluding the rain, but admitting the air. These pyramids are watered from time to time with putrid urine, and, in about a year, saline efflorescences begin to appear on their surface: shortly after, the nitre thus generated is swept off, and the piles then yield regular crops of this substance every week or ten days, except during frosty weather, for about nine years. At the expiration of this period the efflorescence ceases, and the nitre yet remaining in the pile is obtained by lixiviation: the insoluble residue is an excellent manure, and much in request for flax and hemp. In Prussia, nitre is obtained from mud walls composed of loamy earth, night soil, mud from ponds, stable litter, and any other vegetable or animal substances: these being mixed together, and tempered to the consistence of stiff mortar by urine and dunghill drainings, are raised into walls four feet high and about two feet thick, and topped with a slight coping of thatch in

order to shoot off the rain: in process of time, the straw and other vegetables which the walls contain, decay, by which it is rendered more porous, and the air gets admission more or less to its interior substance. Many, however, are the objections to this method of preparing nitre. In the first place, the labour required for the construction of these walls is very considerable: secondly, the clayey loam, which is necessary to give the mass a due consistence for the formation of walls, prevents it from being sufficiently porous, even after the straw, &c. has decayed: thirdly, there is seldom a proper quantity of calcareous matter, so that much of the nitrous acid flies off for want of a fit base to detain it: and fourthly, the very imperfect protection from the weather which these walls receive from their thatch coping, subjects a considerable quantity of the salt, when formed, to be washed out by the rain, and thus lost. For these reasons, it is seldom worth while to lixiviate this earth oftener than once in about six or eight years, and even then the produce is very scanty.

In France, the nitre-beds are composed of nitrous earth from farm-yards, stables, &c. of street sweepings, of mild calcareous earth, such as old mortar or plaister, chalk, tufa, or the sweepings of roads paved with limestone; of animal matter, such as night-soil, blood, refuse from the skinners and tanners, bones and other offal; of vegetable matter, such as straw and stable litter, leaves, sawdust, spent tanner's bark, &c. These are all mixed in somewhat casual proportions, care being only taken that a sufficient quantity of calcareous matter is present; they are laid as lightly as possible in long beds or pyramids, under covered roofs, to protect them from the weather, and are kept duly moistened with putrid water or urine: by this management they yield every other year by lixiviation a considerable quantity of nitrated lime, which, by the addition of woodashes or potash is converted into true nitre. The circumstance in which the French nitre beds differ principally from those of Sweden and Germany, is, that they scarcely ever contain woodashes, the requisite portion of alkali being added in a subsequent part of the manufacture.

The proportion of nitre afforded by these artificial beds it is not easy to ascertain. In France, where the custom is to lixiviate once in two years, the produce may be estimated at from 7 to 12 ounces of nitre from 100 lbs. of materials: of this about half is nitrat of potash, and the rest nitrat of lime, requiring therefore the addition of potash to convert it into true nitre.

Concerning the theory of nitrification much has been written, but, with the exception of an admirable memoir by Mr. Thouvenel, to little purpose. The chemists of the modern school, having discovered that nitric acid is composed of oxygen and azote, and that animal matters abound in condensed azote, content themselves with saying, that the azote, as it is evolved by the progress of putrefaction, combines with the oxygenous part of the air, and thus forms nitric acid, which is prevented from escaping by the lime and other alkaline bases with which it is in contact. This, however, from the little hitherto known on the subject, appears to be a very imperfect representation of the matter; we shall therefore proceed to detail the principal results of M. Thouvenel's experiments; which, imperfect as they are, throw more light on this curious and important subject than any others with which we are acquainted.

Several open vessels, containing each three lbs. of pure and well washed chalk, moistened with distilled water, were, for the space of seven or eight months, exposed to the putrid vapours of privies, cellars, and prisons: being then lixiviated, they afforded from 50 to 90 grs. of nitre each, of which the principal part was nitrat of lime, but mixed in general with a little nitrat of potash. From other similar experiments, M. Thouvenel ascertained, that in close confined situations, where there was hardly any circulation of air, and on the other hand, that in places where the external air passed in a free current, the production of nitre was by no means so copious as where the putrid fumes remained for a long time in contact with the chalk, and were only occasionally diluted with atmospheric air. In those places most favourable to the generation of nitre, were exposed, together with the vessels containing chalk, others with a like quantity of quicklime, with magnesia, both mild and caustic, with earth of alum, and with the fixed alkalies, both mild and caustic. They were all examined after the expiration of 8 months: the saline contents of the chalk we have just mentioned; the quicklime, the caustic, and mild magnesia, afforded from 6 to 7 grs. of earthy nitrat mixed with a little ammoniacal nitrat; the earth of alum yielded a still smaller proportion of nitrat, and the fixed alkalies none at all. The results of these experiments being ascertained, another series was undertaken and conducted in the following manner. An earthen cucurbit was fitted to a

very large receiver of the same materials pierced with a few small holes so as to allow of a partial communication between its contents and the outer air: in the cucurbit was put some putrid blood, and in the receiver were placed open vessels containing a few ounces of lime, magnesia, earth of alum, and the fixed alkalies, both mild and calcined: 21 other receivers furnished in the same manner were connected with cucurbits charged with various putrescent mixtures. The gas, as it was disengaged from the materials in the cucurbit, passed into the receiver, mixing with the atmospherical air, and surrounding the enclosed earth and alkalies. After this process had been continued for a year or more, the contents of the receivers were examined; in all of them the chalk was found to contain nitrat of lime, but varying in proportion from one to 5 grains per oz. The quicklime, the magnesia, and earth of alum, in most of the experiments, had acquired no nitric acid, but in some a little earthy nitrat was formed. The fixed alkalies, as in the former experiments, had acquired no nitric acid whatever. It was further observed, that although the chalk in most of the experiments showed signs of nitrification in about a month's time, and proceeded rapidly for the first three months, yet after this period the progress was very slow, no doubt, because the oxygen of the atmospheric air originally contained in the receivers having been consumed, the gradual pouring in of putrid gas from the cucurbit almost entirely preventing the external air from entering through the small holes that had been drilled for this purpose.

It appearing from the above experiments, that the fixed alkalies and the alkaline earths themselves when caustic are very little capable of absorbing nitric acid from a mixture of putrid gas and atmospheric air, M. Thouvenel was induced to try whether this was owing to any change produced on the putrid gas by these bodies. For this purpose, having charged a retort with putrefying materials, he connected with it three receivers in the manner of Woulfe bottles, the last of which terminated in a tube communicating with a pneumatic apparatus. Four different sets of this apparatus were employed at the same time. In the first of these, the two receivers nearest the retort were charged with four ounces of chalk diffused in distilled water, while the third receiver contained a solution of caustic potash. In the second set, the two first receivers contained distilled water, and the last was charged with the washed chalk. In the third set, the two first receivers contained limewater; and in the fourth set, a solution of caustic potash, the third receiver in both cases holding the chalk. They were all equally exposed to the same temperature, namely, from 74° to 80° Fahr. for six months, and the changes which their contents had undergone were then examined.

The chalk in the first apparatus afforded 26 grs. of nitrat of lime mixed with a little nitrat of ammonia; the potash in the third receiver had become saturated with carbonic acid, and had partly crystallized on the side of the receiver, but contained no nitre.

In the second apparatus the water of the two first receivers had acquired a very putrid smell from the gas which had passed through it, and contained a little ammonia, but afforded no nitrous salt on evaporation: the chalk in the third receiver afforded by lixivation no more than four grains of nitrated lime.

In the third apparatus the lime water had deposited its earth in the state of carbonat, and the supernatant fluid had a strong odour resembling ammonia and putrid garlic: by evaporation it yielded five or six grains of nitrated ammonia. The chalk in the third receiver gave only a slight trace of nitrat of lime.

In the fourth apparatus the potash was crystallized but contained no nitre: with sulphuric acid it effervesced strongly, giving out a very pungent and highly fetid gas: the chalk in the third receiver gave no indications whatever of the presence of any nitrous salt.

The gas remaining in the receivers and collected in the pneumatic apparatus was, in all the four experiments, found to be slightly inflammable, although when rising from the putrefying materials it extinguished a taper immersed in it. This putrid inflammable gas was incapable by itself of nitrifying chalk, but, when mixed with washed atmospheric air, carbonic acid soon made its appearance, and then the gas became incapable of impregnating chalk with nitrous acid as at first.

The above experiments were undertaken when pneumatic chemistry had as yet made but little progress, and therefore the deductions from them are by no means equivalent to the labour and time employed in carrying them on: it appears however, that we may legitimately draw the following conclusions. In the first place, the formation of nitric acid from animal matter in putrefaction, is not owing to atmospheric air, being presented to the azote when in a nascent state; for this change takes place after the azote and

other gazefiable substances, have actually assumed the elastic form. Secondly, the elements of the putrid gas, are carbonic acid, azote, hydrogen and carbon, not mixed but combined together, though weakly: this combination is in part destroyed by mere washing in water, but more completely by the action of those alkaline bases, that are not completely saturated with carbonic acid; when the carbonic acid is abstracted, the further decomposition of this gas by atmospheric air, tends more to the production of ammonia and carbonic acid, than of nitric acid. Washed chalk after being thus nitrified often contains a little nitrat of potash, as well as nitrated lime: it does not however, hence necessarily follow, that potash is also a product of putrefaction; for it may possibly pre-exist in the chalk, in a state insoluble in water, as it does in leucite, in the alum ore of La Tolfa, and other minerals. The important practical conclusion to be deduced from these experiments, is, that the only alkaline substance to be admitted in the composition of nitre beds is mild calcareous earth.

Chalk however is not only capable of being nitrified by exposure to the combined action of atmospheric air and putrid gas, but also by means of the atmospheric air alone. On this subject there are some experiments by Lavoisier and Clouet, much to the purpose. The village of Roche Guyon on the Seine, is situated on a ridge of chalk, which, having the character of nitrifying spontaneously by exposure to the air, was on this account visited, and particularly examined by the able chemists just mentioned. In order to ascertain whether this chalk before the action of the air contained any nitrous salt, selection was made of a part of the rock which had recently been laid bare, by the falling down of a large mass. In this newly-exposed face of rock, a gallery had been driven, of which the further extremity had been excavated only two or three days before. In order to render the experiment as unexceptionable as possible, about a foot more of chalk was removed from the extremity of the gallery; after which a specimen of the weight of 12½ lbs. was dug out, and subjected to lixiviation: by evaporation of the fluid, there were deposited four grains of muriated soda; and the small residue of mother water, afforded, by the addition of carbonated potash, 53 grains more of salt, which appeared to be muriat of potash, with perhaps a slight admixture of nitre: for although it did not detonate in the smallest degree with charcoal, yet by sulphuric acid it gave out acid fumes, in which the odour of nitro-muriatic acid was just perceptible.

It appears, that chalk composing many rocks, though perhaps not absolutely and entirely destitute of nitric acid, even at their centre, is much more abundant in this substance, in proportion as it is situated near their surface; and that the perfect nitre or nitrat of potash, is only found near the surface of the chalk: a circumstance which seems to shew, that both the acid and alkali, have been either deposited from the air, or formed by the contact of this latter with the chalk. In confirmation of this deduction may be mentioned, an experiment by the Duc de la Rochefoucault, who lixiviated a considerable quantity of chalk, so as to dissolve out its saline contents, and then exposed it to the action of the air for fourteen months, during which period, it had acquired not only nitric acid but potash, since the liquor of the second lixiviation deposited by evaporation a little nitre, and afterwards a considerable quantity more on the addition of potash. These facts having never been called in question, the next inquiry that occurs, is whether the atmosphere furnishes the entire nitric acid, or only one of the constituent parts of it? That this latter is the case, might be inferred from the frequent occurrence of organic remains, and impressions in chalk, whence this mineral may be supposed to be by no means destitute of animal matter. Against this however, there may be alleged a direct experiment by M. Thouvenel, who, on exposing some washed chalk, for six or seven months to a portion of atmospheric air, confined in a large receiver, and previously well *washed* in distilled water, found that not an atom of nitrat of lime was generated; while in a similar experiment, in which washed chalk was exposed to *unwashed* air, a very sensible quantity of nitrated lime was produced. Now the washing could not separate the azot or oxygen, though it might and no doubt would take away any nitric acid ready formed, or any nitrous salt that might be contained in the atmosphere. It is observed of these chalk rocks, that those parts that are adjacent to inhabited buildings, yield a greater proportion of nitrat of *potash* than those which are at a distance from houses; a circumstance that seems to point out a probable source of the alkali, without supposing it to be generated, either in the air or chalk. It is well known, that the common fuel in France is wood, therefore the air in the vicinity of houses, must be more or less impregnated with pyroligneous acid contained in the wood smoke; but the acid

vapour that flies off in the common method of preparing charcoal (and which is no other than pyroligneous acid) when collected in a proper apparatus, condenses into a sour liquid, from which, by gentle evaporation, a black residue is procured, that yields by incineration a large proportion of potash.

It only remains to give an account of the extraction of nitre, from the earths in which it is contained, and of the purification of this salt.

The first thing is to assay the earth. This is done by lixiviating a few pounds of it, and adding to the liquor thus obtained, as much of a solution of common potash of a known strength, as is sufficient to decompose all the earthy salts. From this assay the quantity of alkali required is easily calculated.

The next process is the lixiviation; which is performed in the following manner. Several cart-loads of nitrous earth are mixed as accurately as possible, with the requisite quantity of alkali, either in the form of wood-ashes or pulverised potash. Several large casks with perforated false bottoms, are then filled with the prepared earth, laid on very lightly; after which as much river water is poured in, as the vessels will hold. In two or three hours time, the cock at the bottom of each cask is turned, and the liquor is allowed to drain out, during the remainder of the day. The casks of a second series charged with earth as before, are new filled up with the first lixivium, and after standing for a few hours, the liquor, thus concentrated, is drawn off in the manner just described. By a similar process on the third day, a lixivium thrice as strong as the first is obtained, which is now sufficiently concentrated, to be boiled down. The contents of each series of casks, are lixiviated twice more, and the weak solutions thus obtained, are employed instead of water, in the first and second lixiviations of fresh parcels of earth.

The boiling down and evaporation next succeeds. The lixivium, containing nitrat of potash, the muriats of potash and soda, with probably a few other salts, and various earthy and other impurities, is put into a large boiler like a salt pan, and heated nearly to ebullition; it is then clarified by the addition of bullock's blood, or a solution of glue, the impurities, as they appear on the surface, being carefully skimmed off: when no more froth rises of itself, a little lime-water is added, which coagulates the remainder of the blood and glue, and thus completes the clarification. It is now boiled for several hours, and the muriats of potash and soda as they deposit, are withdrawn by a perforated ladle. When the liquor is so concentrated, that a few drops crystallize readily on being dropped on a cold iron, it is laded out into a vat, where it remains half an hour to deposit the common salt and impurities, still floating in it: hence it is transferred to large wooden or metallic crystallizing basons, where it remains close covered up, during from three to six days, according to the temperature of the air; at the expiration of this period, the fluid mother water is poured out and returned to the nitre bed, and the salt deposited in a confused crystalline mass of an opake dirty white, is broken to pieces and set to drain, after which it is brought to market, or delivered into the government stores, as rough nitre or nitre of the first boiling.

In order to refine the rough nitre, the ancient practice was to subject it to two more successive boilings and crystallizations; by this method, however, a very considerable proportion of the nitre was left in the mother waters, no inconsiderable share was volatilized, by the heat required for evaporating the solution, when it had nearly acquired the due degree of concentration, and besides a great expense both of time and fuel was incurred. The modern method of refining this salt was invented in France, a few years ago, and is now considered as brought nearly to perfection. It is thus effected:

The rough nitre is broken to small fragments by wooden mallets, and is then put into a wooden tub, with 20 *per cent.* by weight of cold water; in this state it remains for six or seven hours, being occasionally well stirred up, that the water may have free access to every part. The water is now let out by a hole at the bottom of the vessel, and carries with it in solution all the deliquescent salts, and the greatest part of the muriats of soda and potash, together with some nitre. When the whole of the liquor is drawn off 10 *per cent.* more of water is added, and well mixed with the nitre for an hour's time, when it is discharged in the same manner as the first. Lastly, 5 *per cent.* of water is poured in and run off again, almost immediately after. The nitre thus washed, after being well drained, is put into a boiler with half its weight of water, and boiled till a pellicle forms on its surface; the liquor is then discharged into a large leaden cooler, and stirred about with rakes, till it is quite cold; by which manipulation, the salt is deposited in small crystalline needles. It is now taken out of the liquor, with a perforated ladle and well drained: after which it is wash-

ed with 5 *per cent.* of cold water, and again drained: being then spread out on a large table it dries in a few hours, and is lastly heated over a fire in large basons for two or three hours, at a temperature not exceeding 120° Fahr taking care to stir it all the while; by this treatment it is perfectly purified, and brought to the consistence of fine sand, and is now ready to be manufactured into gunpowder.

In addition to the remarks before made we have been induced to give the following "Instructions respecting the Purification of Saltpetre, drawn up by order of the Committee of Public Safety of Paris; by whose order also this Process is adopted in all the Laboratories of France," from the Repertory of Arts, vol. viii, p 199. Translated from the *Annales de Chimie*.

The crude saltpetre is first to be bruised with wooden beaters, that the water, with which it is afterwards to be washed, may more easily act upon every part of it.

The saltpetre, thus bruised, is then to be carried to proper tubs or vats, in each of which five or six hundred pounds may be put.

Water is to be poured upon the saltpetre, in the proportion of twenty parts to a hundred, and the mixture is to be well stirred.

It is then to be left to macerate or soak, till the liquor will dissolve no more. Six or seven hours are sufficient for this first operation; the liquor then indicates from twenty-five to thirty-five degrees, by the *pese-liqueur*.

This first washing is then to be drained off, and fresh water, in the proportion of ten parts to a hundred, is to be poured on the saltpetre.

The mixture is to be stirred, and left to soak for the space of an hour; the water is then to be again drained off.

Fresh water is to be once more poured on the saltpetre, in the proportion of five parts to a hundred; which water, after stirring, is to be immediately drained off.

This drained saltpetre is then to be put into a cauldron, containing fifty parts of boiling water to a hundred. When the saltpetre is dissolved, the solution ought to indicate from sixty-six to sixty-eight degrees, by the *pese-liqueur*.

The solution is then to be carried to a crystallizing vessel, in which, by cooling, about two-thirds of the saltpetre made use of will be precipitated: the precipitation begins in about half an hour, and finishes from four to six hours afterwards But, as it is of importance that the saltpetre should be obtained in the form of thin needles, because in this form it is more easily dried, it is necessary that the liquor in the crystallizing vessel should be stirred the whole time the precipitation is forming. The stirring is performed by means of a kind of rake, which gives a slight motion to the mass of liquor, and causes the crystals to be precipitated in the form of thin needles.

As the precipitation takes place, the crystals are to be brought to the border of the crystallizing vessel; to be taken up with a skimmer, and put to drain in baskets placed, for that purpose, upon frames, in such a manner that the water which runs from the crystals, may fall again into the crystallizing vessel, or it may be received in basons placed under the baskets.

The saltpetre is then to be thrown into wooden boxes, formed like the hopper of a mill, and having a double bottom. The upper bottom is supported, by means of pieces of wood, about two inches above the lower one, and is pierced full of small holes; through these holes the liquor drains off, and finally passes, through a hole made in the lower bottom, into a reservoir beneath. In these boxes the saltpetre is to be washed, with five parts of water to a hundred; this water may be used for dissolving the saltpetre in future operations.

The saltpetre, after being well drained, and exposed to the air for some hours, upon proper tables for drying it, may be afterwards made use of for preparing gunpowder.

But, when it is intended to make use of the saltpetre for making gunpowder, according to the process followed since the revolution, it must be much more highly dried. This may be accomplished by placing it in a stove; or, what is more simple, by heating it in a shallow cauldron. For this purpose, a layer, five or six inches in thickness, is to be put in the cauldron, which is to be heated to 40 or 50 degrees of Reaumur's thermometer.

The saltpetre is to be stirred for two or three hours, and to be so much dried, that, when strongly pressed in the hand, it does not acquire any consistence, nor retain any form, but appears like fine dry sand.

This degree of dryness is not necessary, when gunpowder is to be made by beating with pestles.

It is then evident that, according to the method of purification we have prescribed, there are two kinds of liquor to consider; first, the water from the various washings of the crude saltpetre; secondly, the water from the crystallizing vessels.

The washing of the crude saltpetre is repeated three times, as we have already mentioned.

In these three operations, thirty-five parts of water to a hundred of saltpetre, according to the quantity of it meant to be purified, are employed in washing.

These washings are founded upon the principle which establishes, that cold water dissolves the muriat of soda, (sea salt) the earthy nitrates and muriates, and the colouring principle, while it scarcely acts upon the nitrate of potash, (pure saltpetre.)

The water from these three washings, therefore, contains the muriate of soda, the earthy salts, the colouring principle, and a small portion of nitrate of potash, the quantity of which is in proportion to the muriate of soda, which determines its solution.

The water from the crystallizing vessels contains that portion of muriate of soda, and of earthy salts, which were not dissolved by the washings, also a more considerable quantity of nitrate of potash than was contained in the water of the washings.

The water which is employed at the end of the process, to wash and whiten the crystals placed in the wooden box, holds in solution only a small quantity of nitrate of potash.

These liquors, therefore, are of a very different nature.

The waters proceeding from the washings, may properly be called mother-waters; they ought to be collected together in basons, and treated with potash, according to the usual method. At the refinery called *de l'Unité*, they are evaporated to sixty-six degrees, and the muriate of soda is taken away as fast as it is deposited; this solution is saturated with potash, in the proportion of two or three to the hundred; it is then suffered to settle, and the liquor is afterwards decanted into crystallizing vessels, in which are thrown twenty parts of water to a hundred, that all the muriate of soda may be kept in solution.

The liquor which remains above the crystals, produced by this treatment of the mother-waters, may be mixed with the water of the first crystallization. The muriate of soda may be separated from this liquor by simple evaporation; and the nitrate of potash, which it holds in solution, may be obtained from it by cooling.

The small quantity of water made use of to whiten the refined saltpetre, contains only nitrate of potash; it may, therefore, be made use of for dissolving the saltpetre in the cauldrons.

From the foregoing account it is evident, that a laboratory destined for the purification of saltpetre, according to the process here described, ought to be provided with the following articles.

1. Wooden beaters for bruising the crude saltpetre.
2. Tubs or vats, in which the saltpetre is to be washed.
3. A cauldron, in which the solution is to be made.
4. A crystallizing vessel, of copper, or of lead, in which the liquor is to be cooled, and the saltpetre crystallized.
5. Baskets for draining the crystals.
6. A wooden box, in which the crystals are to be more thoroughly drained, and the saltpetre washed for the last time.
7. Scales for weighing the saltpetre.
8. Thermometers and *pese-liqueurs*, to determine the degree of heat, and that of consistence.
9. Rakes to stir the liquor in the crystallizing vessel.
10. Skimmers to take off the crystals, and put them into the baskets.
11. Syphons, or cranes, to empty the cauldrons.

The number of these implements, and their dimensions, must necessarily vary, according to the quantity of saltpetre proposed to be purified.

Supposing it is wished to purify ten thousand pounds of crude saltpetre per day; the number of men and utensils, necessary for that purpose, may be determined according to the following calculation.

On Weighing and Bruising the Crude Saltpetre.

A piece of ground must be set apart, as near the magazine as possible, for the purpose of beating or bruising the crude saltpetre.

This ground must be covered with broad smooth stones, or with very thick boards.

For brusing the saltpetre, wooden beaters may be made use of, similar to those which are used for beating mortar.

Two men are sufficient for carrying the saltpetre to the magazine, for weighing it, and bruising it.

On Washing the Saltpetre.

As the three washings take up the space of two days [This neither agrees with the time stated in the beginning of the paper as necessary for the three washings, nor with what has just now been said, that ten thousand pounds may be thus refined per day. We notice this, lest our readers should think our translation erroneous,] and as each of the tubs or

vats will contain only five or six hundred pounds of saltpetre, twenty of them will be necessary for the purification of ten thousand pounds.

These tubs are to be two feet and a half in height, and the same in breadth.

They must be constructed with the greatest care, that the water used in washing the saltpetre may not escape through them.

They should be firmly fixed upon a plane, slightly inclined, of such a nature that the water from the saltpetre cannot soak into it. This plane should be terminated by a gutter, to receive the water from the saltpetre, and to conduct it into a reservoir placed at the end of the row of tubs.

These twenty tubs may be disposed in two parallel lines. The planes upon which they are fixed may be inclined towards each other; so that their union may form the gutter or channel which is to conduct into the common reservoir the water that runs off.

These tubs are to have an aperture at the distance of two fingers' breadth from the bottom; which aperture (besides the stopper which closes it) must have a grated or perforated cover.

Four men may be allotted to the washing of the saltpetre: they should also have the charge of carrying the saltpetre from the magazine to the tubs, and from the tubs to the cauldron.

It is hardly necessary to mention, that the tubs should be separate from each other, and disposed in such a manner that they may be easily served.

On the Cauldron.

A conical cauldron, five feet broad, and four feet deep, will supply three operations in the day; and consequently will suffice for the purification of fifteen thousand pounds of saltpetre.

One man is sufficient for the service of the cauldron.

On the Vessel for Crystallization.

The crystallizing vessel should be made of lead, or of copper, and should be placed as near the cauldron as possible.

It should be fifteen inches in depth, ten feet in length, and eight in breadth.

It should be fixed upon very solid ground, in such a manner that every point of the bottom may be supported. The stone or brick work on which it is placed, should be raised twelve inches above the ground; by this means, the brink of the crystallizing vessel will be twenty-seven inches above the ground, which will render the service of it more easy and convenient.

It appeared to us advantageous, to give the bottom of the crystallizing vessel an inclination of four inches (in the longitudinal direction only) from the sides to the centre.

The solutions from the cauldron may be emptied several times successively into the vessels, after having taken away the deposition of crystals arising from each solution.

Four men seem necessary for the service of the crystallizing vessel. They must keep the liquor constantly stirred, by moving the rakes therein; they must continually bring towards the edges of the vessel the crystals which are formed; they must take them out with a skimmer, and carry them to the baskets which are to receive them, and in which they are to drain.

The same men may put the saltpetre into the wooden boxes in which the draining is completed, and may afterwards carry it into the magazine for purified saltpetre.

For want of a large vessel for crystallization, a shallow cauldron may be made use of.

On Drying the Saltpetre.

To render the saltpetre fit to be made use of in the preparation of gunpowder, as soon as it is purified, it may be dried by either of the two following processes. First, by exposing it to the open air, or to the sun, during some hours, upon such tables as are used for drying gunpowder. Secondly, by putting it into a shallow cauldron, and keeping it, for the space of two hours, in a heat of from 40 to 50 degrees.

In either case, the saltpetre must be incessantly stirred and shaken, that it may dry quickly and equally.

General Remarks on the foregoing Process.

A pretty long experience has shown us, that the process here described is the most simple, and the most economical.

But, to spare others the trouble of trying such means of improving this process as have occupied our attention, but which we thought it right to reject, we shall submit to them the following reflections.

1. It has been tried to dissolve the crude saltpetre; to crystallize it; and afterwards to wash it, in order to separate the sea-salt from it.

This process at first sight appears more advantageous, because it is then unnecessary to bruise the saltpetre, but it is attended with great inconveniences.

First, the crude saltpetre, dissolved in fifty parts of water to a hundred, and poured into the crystallizing vessel, does not deposit the same quantity of saltpetre as when it is washed before it is dissolved. This difference takes place, because the sea-salt, which exists in the crude saltpetre, facilitates the dissolution of the nitrate of potash; and consequently, the water in the crystallizing vessel must necessarily hold in solution a greater quantity of nitrate of potash, when the crude saltpetre is dissolved, than when it is previously washed in cold water, and thereby deprived of the sea-salt it contained. Secondly, the washing of the saltpetre, when done after its dissolution and crystallization, requires forty or fifty parts of water to a hundred, instead of thirty-five.

2. It has been tried to dissolve the saltpetre in twenty or twenty-five parts to a hundred; to take away the muriate of soda, as fast as it is precipitated by the boiling of the liquor; to dilute this solution with thirty parts of fresh water to a hundred, and then to carry it to the crystallizing vessel. It was supposed, that by this means, the washings with cold water might be omitted, or considerably diminished. But, a continued boiling, kept up for four or five hours, in order to separate the sea-salt, is attended with a great waste of time, of fuel, and of saltpetre; and the washings are still indispensably necessary, both to take away the colouring matter, and to extract the last portions of sea-salt.

3. It may be supposed, that it would perhaps be possible to diminish the quantity of water used in washing; but we must observe, that it is to be feared, that when the saltpetre contains a great quantity of sea-salt, the purification of it would not be complete, if a less quantity of water were made use of than that we have prescribed.

4. One might perhaps be tempted to diminish the quantity of water made use of in the solution; but we are convinced, by repeated experiments, that the proportion we have pointed out is the most proper: if it is augmented, the saltpetre remains dissolved in the liquor; if it is decreased, it congeals or precipitates itself in a mass. We found, by observation, that the degree of saturation, most proper for our operations, was between the sixty-sixth and sixty-eighth degree of the *pese-liqueur*.

5. It might also be thought, that it would be more simple, and more economical, to treat the solutions of crude saltpetre with potash; but it is to be feared, that by so doing, a part of this alkali might have the effect of decomposing the muriate of soda, and converting it into muriate of potash; and it must be observed, that the last-mentioned salt is by no means proper for decomposing earthy nitrates, whatever some able chemists may have said of it.

It therefore appears more proper, not to treat the mother-waters, nor to make any use of potash, till all the sea-salt has been separated by evaporation.

During the American revolution the attention of Congress was directed to the resources of saltpetre for the manufacture of gunpowder, as well as to the best means of purifying it. Several essays accordingly appeared, which had the desired tendency. Saltpetre was manufactured by the corruption of animal and vegetable substances, and its manner of purification was accordingly improved. The floors of tobacco houses were dug up, and elixated for the purpose. But at this period, the United States is supplied from the nitre caves in the western country, of which some account is given in the beginning of this article.

O.

OAT. See AGRICULTURE.

OCHRE. In a general sense, ochre is an earth coloured with oxyd of iron, and sometimes with other metallic oxyds. Ochres are yellow, red, and brown. They are used as pigments, and for this purpose are considerably employed. They are found in abundance in the United States. They constitute a variety of the argillaceous genus. Some of them are altered by calcination, hence the conversion of the yellow to the red, by that process. This is owing to a further oxydizement of the metal. The ferrugineous or iron ochres are the most common, and appear to have been formed by the decomposition of iron pyrites, or by the gradual oxydizement of iron in contact with clay.

OCHRE, YELLOW }
OCHRE, BURNT } See COLOUR MAKING.
OCHRE, ROMAN }

A very fine yellow ochre may be made

by decomposing copper as (sulphate of iron,) by the addition of potash or lime. Hence yellow wash for rooms, is often made by mixing copperas with half its weight of lime, in a sufficient quantity of water. The acid unites with the lime into sulphate of lime or gypsum, and the iron is precipitated in the form of oxyd, which, by mixture with the gypsum, forms the wash.

OIL. The distinctive characters of oil are inflammability, insolubility in water, and fluidity, at least in a moderate temperature. Oils are distinguished into fixed or fat oils, which do not rise in distillation at the temperature of boiling water; and volatile or essential oils, which do rise at that temperature.

Fixed oils are obtained by pressure, sometimes assisted by heat, or by boiling in water, from the emulsive seeds or kernels of vegetables; and likewise from the fatty parts of animals. They are generally fluid in the temperature of the atmosphere, but some of them have a considerable degree of firmness or solidity. They have a very smooth feel; require a degree of heat much superior to that of boiling water, to cause them to rise in ebullition; and cannot be set on fire, unless heated to this degree. The use of the wick of a lamp consists in bringing small portions of oil to its extremity, by the capillary attraction; where they become successively volatilized and inflamed. Oils are remarkably less sonorous than water, when poured out. Fat oils, not being at all dissipated by the heat of the atmosphere, make a permanent greasy spot, when they fall on porous substances.

These oils are decomposed by distillation, and afford a small quantity of water loaded with a peculiar acid, a light oil, a dense oil, hydrogen, and carbonic acid gas. The residue consists of a small quantity of charcoal.

In the last analysis of organized substances the results are, hydrogen, oxygen, nitrogen, and carbon, which appears to be their basis. By what combinations or super-compositions, they are made to exhibit the variety of products which come under our observation, can in few respects be ascertained by any experiments we are yet capable of making. Lavoisier, in the Memoirs of the French Academy for 1784, collected the products of olive oil burned in an apparatus properly constructed, to ascertain their nature and properties. He obtained 79 parts of carbon, and 21 of hydrogen, from 100 of the oil. From these component parts, inferences may be formed respecting the acid, the water, the carbonic acid, and the hydrogen gas, afforded by the partial decomposition or combustions of this fluid.

The light oil, produced by distillation of fat oils, is naturally more disposed to fly off by heat, and leaves less coal behind it, than the fat oil itself. This property renders it useful in some of the arts, as those of lapidaries, seal engravers, and others, who grind precious stones with fretting powders. The oil used for this purpose, is known by the name of oil of bricks, which is made by igniting pieces of brick which had imbibed it. In order to form a proper notion of the advantage of this fluid, it must be remarked, that all grinding produces heat; that this heat would speedily evaporate water, and render common oil thick; that, if neither water nor oil were present, the heat would very soon increase to strong ignition, and injure both the tool and the substance operated on. The oil of bricks possesses neither of the bad qualities of the two fluids here mentioned, in so considerable a degree, and is therefore preferred for such work as can afford the expense.

Fat oils, by exposure to the air, become rancid, and exhibit a disengaged acid, which may be washed off by water. When they are exposed to the air, in a thin coat, upon the surface of water, they become more consistent, like wax, by absorbing the oxygen of the atmosphere. The oxygenized muriatic acid produces this change more speedily. Agitation in water, particularly if acidulated, separates a mucilage from them. They combine with barytes, strontia, magnesia, and lime, which convert them into saponaceous compounds. With the pure alkalis they form common soap. They do not unite with ammonia but by long trituration.

The mineral acids unite with fat oils, and form compounds, or imperfect soaps. Fuming nitrous acid causes them to take fire, as has already been observed. Sulphur is soluble in fat oils, by a digesting heat; and is gradually deposited in part from them, in a crystalline form, by cooling.

Fixed oils seem not to be susceptible of combination with pure metallic substances, excepting iron and copper, upon which they act in a sufficiently distinct manner. But they combine with metallic oxydes, and form with them thick concrete combinations, of a soapy appearance, as is observable in the preparation of unguents and plasters. These preparations have not yet been chemically examined. Metallic oxydes are likewise boiled in oils to give them the quality of drying quickly.

Mr. Sheldrake has observed, that oils

thus prepared dry by forming a superficial skin, and the more of this quality they possess, the more colours mixed with them are liable to change by keeping. He therefore recommends, to dissolve amber, or copal, in the oil, to dry by uniform inspissation; and with this to mix the colours previously ground in oil of turpentine.

Mr. Vanherman has lately laid before the Society of Arts, a method of rendering fish-oil applicable to painting; and it appears to make a good and cheap vehicle for colours exposed to the weather, though it dries but slowly. To thirty-two gallons of vinegar, he adds 12 lbs. of litharge, and 12 lbs. of sulphat of zinc, shaking the mixture well, twice a day for a week. The mixture is then put into a tun of fish-oil, with which it is well shaken and mixed; and the next day the clearer part, about seven-eighths of the whole, is poured off. Twelve gallons of linseed oil, and two of oil of turpentine, are then added to the clear part; and this, being well shaken together, is left to settle for two or three days, when it will be fit to grind white lead, and all fine colours in. These however are to be thinned for use with linseed oil, and oil of turpentine.

For cheap paints exposed to the weather, whiting and road dirt finely sifted, are to be mixed with lime water to the consistence of mortar; to this may be added almost any pigment, ground with the sediment of the prepared oil, in the proportion of one part to two, of the lime-water already used; and the whole is to be thinned for use, by adding to every eight pounds, a quart of linseed oil, and as much of a mixture of the prepared oil with lime water. The proportions of this mixture are not mentioned.

If two ounces of litharge be added, to a gallon of linseed oil, and well shaken every day for a fortnight; and the clear part, mixed with half a pint of oil of turpentine, be exposed to the sun for three days in shallow pans, Mr. Vanherman informs us, it will be as white as nut-oil. If half a pound of frankincense be dissolved in a quart of oil of turpentine, and added to a gallon of this bleached oil; and white lead, ground in oil of turpentine, be thinned for use with this mixture; he asserts that it will be quite dry and void of smell in four hours.

It is likewise desirable to purify the coarse fish oils, for the purposes of burning, and of some manufactures. This may be effected to a certain degree, by shaking it with limewater, or with a little chalk, and slaked lime and water. But to purify it thoroughly, an ounce of powdered chalk, a quarter of an ounce of lime slaked in the air, and half a pint of water, should be well mixed, with a gallon of the stinking oil; and when it has stood some hours, a pint of water and two ounces of pearl ashes, should be added, and the mixture kept simmering over the fire, till the oil appears of a light amber colour: then add an ounce of salt dissolved in half a pint of water, boil half an hour longer, and let the mixture stand, till the oil separates. If it be required still purer, the oil after being poured off, may be treated in a nearly similar manner, but without heat, with an ounce of chalk, a quarter of an ounce of pearl ashes, and half an ounce of salt. If an oil of somewhat more consistence be wanted, kitchen stuff may be added to it, while it continues hot.

To purify rape oil for burning in lamps, Curaudeau advises, to add 100 parts of oil, one part of sulphuric acid, diluted with six of water; shake the mixture well; and then let it settle: or one part of wheat flour, mixed with ten of water, and expose it to a heat not exceeding 212°, till the water is evaporated.

In the assaying of metals, fixed oils are sometimes employed to reduce the metallic oxydes. Berthollet has given an ingenious and simple process for effecting instantaneously a real combination, between fixed oil, and metallic oxyde, that is, for preparing a metallic soap. It consists in pouring a metallic solution, into a solution of common soap. The acid of the metallic solution, combines with the fixed alkali of the soap; and the metallic oxyde, is then precipitated in union with the oil, to which it communicates a colour. In this manner, soap of a beautiful green colour, may be prepared with sulphat of copper; and with sulphat of iron, a clear deep brown soap. Fourcroy thinks these compounds might be very useful in painting.

Scheele discovered, that when oil of sweet almonds, olives, rapeseed, or linseed, is combined with oxyde of lead, with the addition of a little water, there is a matter separated from the oil, which swims on the surface of the liquor, and to which he gave the name of the mild principle. On evaporating this supernatant water, the principle dissolved in it, causes it to assume the consistency of syrup: when exposed to a strong heat, it takes fire; one part is volatilized in distillation, without burning: the coal which it leaves is light: it does not crystallize; nor does it seem to be susceptible of fermentation. Nitric acid, distilled on this matter four times successively, changes it into oxalic

acid. This mild principle of Scheele's appears to be a sort of mucilage.

The dense animal oils, such as butter, tallow, fat, the oil of the whale, and the like, exceedingly resemble vegetable fixed oils. They appear, however, to contain a proportion of nitrogen, or animalized matter, probably in the state of serum or gelatine. The volatile oil, obtained by attenuating animal oil, by a number of successive distillations, is called Dippel's animal oil. Macquer observes, that it may be rendered almost as white, thin and volatile as ether, and is then capable of acting upon the brain and nervous system, in a dose of from four to ten or twelve drops, incorporated with some proper vehicle. Rouelle recommends, to rectify it by distillation with water.

It is much more difficult to obtain this oil in a pure state, from fixed oils, than from gelatinous matters, of which hartshorn is to be preferred. It is necessary to change the vessels at each successive distillation, or else to clean them perfectly, because a very small part of the thicker and less volatile oil, is sufficient to spoil a large quantity, of that which is more highly rectified. Beaume has observed, that this operation may be greatly abridged by taking care to receive none but the most volatile part in each distillation, and to leave a large residuum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four distillations, a considerable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 distillations, without attending to this circumstance. And Monnet asserts, that, by mixing acids with animal oil, their rectification may be very much facilitated.

The oil of Dippel must be kept in clean glass bottles, with ground stopples, and exposed as little as possible to the air, because its volatile parts fly off, and the remainder becomes coloured.

Fourcroy distinguishes vegetable fat oils into three classes. In the first, he places such as are congealable by cold, thicken very slowly, by exposure to air, form soaps with acids, and require an addition of sulphuric acid to that of nitre, in order to inflame them.

Most metallic oxyds are decomposed by the fixed oils at a boiling heat: those, however, that are commonly employed for this purpose, are minium and litharge. If either of these substances, ground to a very fine powder, be put in a kettle with a little water and some *fat* oil, and the whole be well mingled by constant stirring, it will be found that the oil, when nearly at the temperature of boiling water, first abstracts part of the oxygen from the oxyd, and then dissolves pretty rapidly the oxyd itself. In consequence of this, the oil becomes thick and coloured, acquires a peculiar odour, and when cooled becomes opake, and of a soft pasty consistence. By continuing the heat after the solution of the oxyd, till the water is completely driven off, the residue on cooling acquires nearly the consistence of wax, and is known in pharmacy by the appellation of *plaster*. If, instead of fat oil, *drying* oil be made use of, the mixture cannot be made harder than stiff paste. Deyeux has shown that fat oils, when previously mixed with mucilage, are exactly similar in this respect to the drying oils. Plaster is not soluble either in alcohol or water, in which respect it differs materially from the proper soaps, to which it has been compared by some chemists. If, after the oil and litharge have combined together, the water is poured off, instead of being dissipated by a further continuation of the heat, and then evaporated considerably in a separate vessel, it will be found to have acquired a thick syrupy consistence and a saccharine taste.

Olive Oil.

The fruit of the olive tree (Olea Europea) when ripe, is of a dark purple colour, and both in size and shape resembles a long plum: it consists of a nut or stone covered by a fleshy pulp, in the latter of which are the cells that contain the oil: the interior nut also contains an oil, but of a bitter disagreeable taste. The fruit as soon as gathered is broken in a mill, care being taken to set the mill-stones at such a distance as to avoid crushing the nut of the olive. The pulp thus prepared is put into bags made of rushes, and subjected to a moderate pressure, by which a considerable quantity of greenish semitransparent oil is obtained, which from its superior excellence is called virgin oil. The marc remaining after this first operation is broken to pieces, moistened with a little warm water, and again returned to the press; a mixture of oil and water flows out, which soon separates spontaneously by rest. This oil, though inferior to the former, is still of a very good quality, and fit for the table. The marc being again broken to pieces, drenched with water, and fermented in large cisterns, is for the third and last time submitted to the full force of the press, by which a considerable quantity of oil is obtained, very valuable to the soapboilers and other manufacturers. In some

countries, particularly in Spain, the olives, instead of being gathered by hand, are beaten down, by which the ripe and unripe are mixed together; to these also are added such as have fallen of themselves, and are therefore more or less decayed. Of this indiscriminate collection a large heap is made, which soon begins to ferment; in this state the olives are ground, and strongly pressed in the usual manner, by which mode of proceeding a larger quantity of oil is indeed obtained, and with less trouble, but of a rank disagreeable flavour, intolerable to any but those who have from childhood been accustomed to it.

Recently drawn virgin oil has a bland almost mucilaginous taste, with a slight but agreeable flavour: if exposed to the air in an open bottle or cask, a white fibrous and probably albuminous matter is deposited, the supernatant oil becoming clear, and of a dilute yellow colour; the oil being poured off into a fresh vessel, a second deposition takes place, after which the oil, if put in clean glass vials, may be kept for a considerable time without alteration. If the oil is allowed to stand on the white matter, it becomes in a few weeks very rancid; and the common oil, even when properly managed, cannot be preserved in casks longer than a year and a half, or two years, at the farthest. The specific gravity of olive oil is $=0.9153$; it boils at about 100° Fahr. and congeals at 36° Fahr. The readiness with which it freezes renders it improper for lamps, especially in cold countries; but by previously exposing the oil in an open clear glass vial to the sunshine, it may be so far amended in this respect, as to continue fluid at 21° Fahr. Olive oil is often sophisticated by poppy-seed oil, and thus is rendered somewhat drying, a property which the genuine produce of the olive never exhibits. In those countries where it is produced, it is employed in food, as butter is with us: the inferior sorts are burnt in lamps, or made into soaps, for the most part of a finer quality than those that are composed of animal oils. It is used in medicine sometimes internally, but generally externally, combined with wax, litharge, &c. into cerates and plasters.

Cornel Oil.

The only oil resembling that from the olive, in being contained not in the seed, but in the pulpy fruit of a vegetable, is cornel oil. The berries of this shrub (Cornus sanguinea, *Linn.*) being collected when quite ripe, and then laid in heaps for a few days in order to mellow, are to be reduced to a pulp, and pressed without heat in the usual manner. By this treatment, from 22 lbs. avoirdupois, may be obtained somewhat more than four wine pints of a fat somewhat viscid oil, of a bright green colour, and equally destitute of any unpleasant flavour as the best olive oil. When heated with nitric acid, it is converted to a lemon-yellow butter or wax. By boiling with litharge, it becomes drying; when spread thin on water, and exposed to the air for a month, it is converted into a white wax. It does not freeze so readily as olive oil, and lasts rather longer than this when used in a lamp.

Almond Oil.

This is procured either from the sweet or bitter almond. The almonds are first put into a coarse hempen or hair sack, and shaken violently, in order to detach, by rubbing against each other and the sides of the sack, the outer brown skin, which if retained is apt to give a bitter taste to the oil: they are then bruised and made into a paste, and pressed in the usual manner. 100 lbs. of almonds afford, by the first expression, 25 lbs. of oil, and from the marc, when impregnated with the steam of hot water, may be procured 15 lbs. more of an inferior kind. Almond oil, when fresh, is of a light greenish yellow colour, and is somewhat turbid, but by time it becomes clear and colourless: it is slightly sweetish to the taste, and has little or no odour. Its specific gravity is $= 0.917$. The degree at which it congeals is variously stated at 19° Fahr. and 8° Fahr.; the former probably relates to the fresh-drawn oil. The only difference between the oil from sweet and that from bitter almonds is, that the latter may be kept the longest without growing rancid. On account of its high price, at least in most of the countries of Europe, it is almost entirely restricted to medical uses.

Poppy-seed Oil, or *Pink Oil.*

The oil is extracted by cold drawing from the seeds of the large white poppy (Papaver somniferum. *Linn.*) which is largely cultivated for this purpose in France, the Netherlands, and various parts of Germany. It is transparent and nearly colourless, and when well prepared has no other taste or flavour than a slight one of nut-kernels. Its specific gravity is $= 0.9288$: it is one of the naturally drying oils, and, like all of that class, is frozen with difficulty; it may be cooled down to 0° of Fahr. without congealing. When employed in food, it is scarcely to be distinguished from olive oil, and indeed this latter is very common-

ly adulterated with it. As to the quantity of oil yielded by a given weight of the seeds, authors are by no means agreed, and much no doubt depends not only on the mode of extracting it, but also on the season and country in which the seeds are produced: from 100 lbs. of fresh seeds, some state the produce of oil at 25 lbs. and others at 58 lbs. It is used both for food and in the composition of varnishes, but is very unfit to burn in a lamp.

Linseed Oil.

The seeds of the common flax, from which this oil is produced consist of a white kernel covered by a thin brownish shell. As it is impossible to separate the shell from the kernel, the entire seed must be submitted to the press; but if thus treated without any previous preparation, the quantity of oil obtained is comparatively small, on account of a strong mucilage that resides in the shell, and absorbs a large proportion of the oil as it is forced out of the kernel. For this reason, and because the cold drawn oil is not so fit for the purposes to which linseed oil is generally applied as that which is hot drawn, the following method is generally taken to destroy the mucilage before the application of the press. An iron vessel like a sand-bath, and capable of containing some bushels, is fixed in a furnace: it is then filled with linseed, and heated by a moderate fire, care being taken to stir up its contents from time to time, that every part may be equally roasted; at first there arises an abundance of aqueous vapour, which, as the heat is increased, is followed by dense blackish fumes of a very nauseous odour. The torrefaction being completed, the paste is pressed in the mill in the usual way.

The proportion of oil yielded by this seed is about 20 per cent.: its specific gravity is = 0.9403. It is not congealed except by a cold below 0° Fahr. its point of ebullition is about 600° of the same thermometer. The cold drawn oil has a high yellow colour, is very unctuous and unpleasant both to the taste and smell; by exposure to the air and light, it becomes drying. The hot drawn oil is of a high yellowish red or deep wine colour; it is still more nauseous than the former; it is of a thicker consistence, and dries without much difficulty in the air, more especially if it has been boiled with a little litharge. Linseed oil is employed a little in medicine; but the great demand for it is in the coarser kinds of painting, particularly such as is not much exposed to the weather, as floor cloths, &c.

Hempseed Oil.

This oil is of a green colour, and is strongly impregnated with the peculiar odour of the plant. The proportion of oil that hempseed affords is from 20 to 25 per cent. In its general properties, uses, and mode of preparation, it closely resembles the preceding.

Oils of Mustard-seed, Cole-seed, Rape-seed, and Sunflower-seed.

These oils are less coloured and less highly flavoured than the two preceding; they are very little liable to dry by exposure to the air, which, together with their moderate price, induces a large consumption of them by the wool-dressers, in order to preserve the wool from the attacks of moths and other insects; and by the leather-dressers.

Nut-Oil.

This is obtained chiefly by cold drawing from the kernels either of the walnut or of the hazle-nut. In the warm climate of the south of Europe these fruits come to their full perfection, and will yield by proper management full half their weight of oil. Recent cold drawn nut oil is by many preferred to olive oil on account of the exquisite nut flavour which it retains: the hot drawn has an empyreumatic taste, and is no longer fit for the table; it is, however, in high request by the painter, as being eminently drying, much less coloured than linseed oil, and capable of bearing the injuries of the weather better than any other oil.

Beech-nut Oil.

Several ineffectual attempts have been made to manufacture this oil with profit from English beech mast. Various causes have probably concurred to occasion the failure, particularly the inexpertness in the method of extraction, and in all probability a real defect of oil compared to that contained in the beech-nuts of France and the south of Germany. The following is the method adopted by some manufacturers, and appears upon the whole to be the best. The nuts, when separated from the outer prickly receptacle, are passed through a mill, the stones of which are set sufficiently wide to break off the outer shell without materially bruising the kernel, after which, by means of the common winnowing machine, the shells are got rid of. The decorticated nuts are then thrown into scalding water, and all those that swim are rejected as being mouldy and worm eaten, and therefore communicating a bad taste to the oil: the

rest are reduced to a pulp, and then cold drawn, when they will be found to yield 15 per cent. of a clear light coloured nearly insipid oil, to the full as good as common olive oil. The marc being now slightly torrefied and again pressed, will afford 12 per cent. more of an inferior oil, and the dry residue is an excellent food for cattle, much better than common oil cake.

Oil of Ben. Oleum Balani of the ancients.

This oil is procured by expression from the decorticated seeds of the Guilandia Moringa, a tree that grows in Ceylon, Ethiopia, Egypt, and Arabia. 100 lbs. of the seeds yield 23 lbs. of a yellowish limpid oil, inodorous, insipid, and which does not become rancid by exposure to the air. On this account it is much used by the Italians as the basis of their perfumed oils, which are commonly prepared by filling a covered dish with alternate layers of cotton soaked in Ben oil, and flowers of jasmine, violet, orange, &c. after the dish has been set in hot water, or in the sunshine for a few days, its contents are unpacked, and the oil squeezed out of the cotton, which by this simple process is found to be highly impregnated with the aromatic qualities of the flowers.

There are several other kinds of expressed oils employed in various countries as food, or in lamps, &c. but of which we shall only particularize the two following, as being specimens of the vegetable butters.

Butter of Cacao.

This oil is procured from the chocolate nut, the fruit of the Theobroma Cacao. The nuts are first gently roasted till the thin outer husk shells off, and are then beaten up into a smooth thin paste by the addition of eight times their weight of warm water. This mixture being then kept at a gentle boiling heat for some hours, a liquid oil rises to the surface, which, when the fire is withdrawn, concretes into a sebaceous matter of a gray colour, and amounting to about 45 per cent. of the entire nuts. This oil may be rendered nearly white by repeated washing in scalding water. It has little or no taste, but retains for a long time the delicate flavour of chocolate, and appears to be the least disposed of any of the oils to become rancid. It is employed in America as an article of food, and in the composition of unguents and medicated soaps.

Palm Oil.

Many of the palms produce a hard nut like a date stone, but abounding in oil. Of these the two principal are the Cocos butyracea and Elexis guineensis. The fruit when ripe is heaped up and slightly fermented, in order in some measure to soften it; being then coarsely pounded, it is macerated in hot water, and thus by degrees parts with its oil, which collects on the surface of the water, and by cooling concretes into a solid cake: it is purified by washing in hot water, and is then fit for use. It has a light lemon yellow colour, little or no taste, but a high odour and flavour like that of the Florentine iris: by long keeping it becomes rancid, and then is nearly white and almost without odour. It is largely used by the negroes in Africa and the West Indies as food, and in Europe is employed in medicine, and in the composition of the best yellow soap.

Oil of Sun-flower seed.

Dr. J. Morgan, in the Transactions of the American Philosophical Society, has given an essay on this subject, of which the following is a summary.

The grinding of the sun-flower seeds, and expressing of oil from the same, is a manufacture, which, as far as can be yet learned, was first begun among the Moravian brethren at Bethlehem, and reflects honour upon them, whilst it affords the public a new substance very beneficial in a variety of purposes, but more especially, as it may serve for a sallad oil, and for other uses of diet and medicine, in the place of olive oil.

From experiments already made at Bethlehem, it is found that a bushel of the sun-flower seed will yield, on expression, near a gallon of mild oil. The gentleman, who is appointed by the community there to superintend their mills, designs, as we are informed, to pursue a further course of experiments on this subject, the result of which, we hope, will be communicated to this society.

Our correspondent at Lancaster informs the society, that some persons in the neighbourhood of that place, have also expressed a quantity of oil from the seeds of the sun-flower. His account is as follows.

The person, who has raised the greatest quantity of the sun-flowers with us, informs me, that one hundred plants, set about three feet distance from each other, in the same manner as Indian corn is commonly planted, will produce one bushel of seed, without any other trouble than that of putting the seed into the ground, from which he thinks one gallon of oil may be made. I observed the land, on which he planted the sun-flowers, to be of the middling sort, and that he took no pains to hill them, or even to loosen the ground

about them, which, from my own observation on some planted in a neighbour's garden, I take to be of considerable use.

As the sun-flower is a plant of great increase, and requires much nourishment, hilling does not seem so good a method as that of setting the seed or plant in a hole, and when the plant is about a yard high, to throw in the mould round the stalk, so that the surface of the ground may be even about it. By an estimate made it appears, that one acre of land will yield to the planter between forty and fifty bushels of seed, which will produce as many gallons of oil. The process for making or extracting the oil is the same as that of making linseed oil, which I make no doubt the Society is acquainted with, and therefore shall not trouble you with it.

The success attending the trials already made, give the greatest encouragement to prosecute this useful discovery. And as the seeds of the sun-flower are at this time nearly ripe, and in a proper state for extracting the oil from them, it may be of service to lay these facts before the public. Such as may have an inclination to make trials on this subject, and are not at present furnished with a sufficient quantity of seed for pressing out an oil, may now supply themselves with enough to plant for making experiments the ensuing year.

For the information of those who have both opportunity and inclination to extend the inquiry, and render this a valuable branch of business, but are not acquainted with the general principles upon which oil is obtained, by expression from vegetable substances, it may be proper to observe, that the kernels of fruits, such as walnuts, hickory nuts, filberts, almonds, peaches, &c. and the seeds of many plants, as mustard, rape, poppy, flax, sun-flower, &c. contain a large portion of mild oil. In order to obtain the oil, the kernels or seeds are commonly rubbed to powder, or ground in mills. They are then put into a strong bag, made of canvas or woollen cloth, and committed to a press between iron plates; by which the oil is squeezed out, and is received or conducted into a proper vessel to collect it The plates of the press are often heated, either in boiling water or before the fire. Many heat the mash itself in a large iron pot, stirring it about with a stick or piece of wood, to prevent its burning, which, when it happens, greatly injures the oil, and gives it a burnt smell and taste, or disposes it to become rancid in a short time. When the oil is drawn without the assistance of heat, it is known by the name of cold drawn oil, and is more valuable than when heat is used, but it is not obtained in the same quantity. It is milder, and may be kept longer without spoiling.

In a cold season of the year, a certain degree of heat is absolutely necessary. But if the oil is designed for aliment or medicine, the plates of the press should be heated in boiling water only. When the oil is intended for other uses, the plates may be made hotter, as heat expedites the separation of the oil, and gives a greater produce; but then care should be taken not to injure the subject by burning.

Sometimes the subject, when ground, appears almost like a dry powder. It is then said to be meagre, and requires to be exposed to the vapours of boiling water, which is done either by tying it up in a bag, or putting it into a sieve, and placing it over the steam. By this impregnation, it will yield its oil more readily, and in greater quantity. The oil may be easily freed from any water that may happen to be pressed out with it, as a spontaneous separation between them will take place on standing for some time.

For the encouragement of those who may choose to improve this subject, it may be proper to observe, that all the oils, from whatever vegetable substances they are drawn, when obtained by expression with due caution, agree in their general qualities, and are constantly mild, even though they are obtained from very acrid substances. Thus the expressed oil of mustard seed is, when fresh, as mild as that of olives, and the bitter almond, or peach kernel, affords an oil, by expression, as mild as that of sweet almonds It is upon this principle, that the sun-flower oil may prove equally valuable with the best Florence oil, for diet or medicine. For every expressed oil, when pure and fresh, is void of acrimony, and free from any particular taste or smell.

Besides the mild oil just mentioned, some substances contain another kind of oil, called their essential oil, a part of which may be drawn off with the mild expressed oil, so called, and impart its smell or taste to that oil. It is called essential oil, from its yielding the particular odour of the vegetable, or part of the plant, from which it was obtained; it is pungent to the taste, and soluble in spirits of wine, which the other is not. They may, therefore, be easily distinguished from each other.

The oil of sweet almonds, and the oil of olives, being pure unctuous expressed oils, not soluble in spirits of wine, but

mild to the taste, and void of odour, very soft, emollient, and lenitive, are chiefly used in medicine and diet. And the reason why the oil of olives, in particular, is preferred, is because it is less expensive, and will keep a much longer time without becoming rancid.

Perhaps, on trial, the sun-flower seeds may be found to contain an oil that will answer the like good purposes with the sallad and medicinal oil now in use. If so, it will have this advantage over that of almonds or olives, that it is a native of the country, may be always had fresh, and at a small expense. Whereas the others are the produce of distant countries, bear a high price, and are often adulterated on that account; or, being kept a long time, they lose their mild quality, and become rancid and acrimonious.

The practicableness of getting oil among ourselves at a moderate expense, and the importance of using it fresh, together with the probable uses of sunflower oil for varnishes, for the basis of ointments, and for mixing of paints, as well as other purposes to be answered by oils in general, claim our attention to this subject, and encourage further trials of the like kind.

Before we quit this subject, it may not be amiss t mention, that castor oil is justly celebrated for its medicinal qualities. The plant, from the seeds of which it is got, may be easily cultivated in this country, and the increase of it is very great in a short time; might it not then be worth the attention of our farmers to propagate this plant for the sake of its oil? We would just suggest, that perhaps it might be worth while to try whether the seeds of sumach, with which this country abounds, or of the mullein, which grows in old fields, and bears a great quantity of seed, would not yield by expression, a valuable oil for medicine or other purposes.

Bene seed Oil.

On the subject of the bene seed oil, the following letter of Mr. John Morel to Mr. Charles Thompson, secretary of the American Philosophical Society, at Philadelphia, dated Savannah, May 5, 1769, may be useful.

"I send you a small keg of bene, or bene seed, which you will please to present to your Society for their inspection. This seed makes oil equal in quality to Florence, and some say preferable. Some say one hundred weight of seed will produce ninety pounds of oil, others say less; be that as it will, it certainly makes very fine oil, and produces amazingly. If it is put to the trial, care should be taken to have the press well cleaned, so as to leave no tincture from what may have been already pressed; in my opinion, this is an article of consequence, and I believe it will grow in Philadelphia. The way to sow it is in holes about three feet asunder, dropping in each hole about ten grains; when it comes up, thin it to three or four of the most promising: the seeds will appear in pods about September, and should, when full grown, and before dry, be gathered in. The method is as follows: As soon as you perceive about three-fourths, or four-fifths, of the pods rise on the stalk, and the lower pods begin to loose their seeds, it is then time to take it in; for after that, as much as ripens one day at top, so much falls out of the pod at bottom. You take a sharp hatchet-bill, or some such weapon, and with it cut off the stock twelve to eighteen inches below any of the seed, holding the stock with the left hand, and when cut, a second person receives it, keeping it upright, till he has his load; for if you turn it downwards, the ripe seed will fall out of the pods. You may immediately carry it into a barn, and set it upright on a close floor, till you perceive all the pods fully dry and open; (you may, if you choose, leave it in the field, which must be the case, if a large quantity is planted,) then thresh it, and run it through a proper sieve, and it is fit for use.

We are quite unacquainted with the method of expressing the oil, but we believe if it is designed for table use, nothing should be done to the seed, as it might give it an ill taste. The lighter and drier the soil is in which it is planted, the better.

Vegetable, Essential, or Volatile Oils.

These oils are so called, because they are evaporable, at a moderate heat, without decomposition, and because in them the odour or fragrance, or as it was called by the old chemists, the *essence* of vegetables resides. They are not confined to any particular parts of a plant, but exist in minute cells distributed through the root, the wood, the bark, the leaves, the blossoms, and seeds. The part in which they occur less frequently than any other, is the lobe or cotyledon of the seed, the peculiar seat of the fixed oil, while the husk or cover of the seed is always more or less impregnated with volatile oil, the acrimony of which defends, in some degree, the rudiments of the young plant from the depredation of insects.

The method of extracting the volatile oil differs, for the most part, very materially from those which we have already described, as practised for the fixed oils.

Those which are procured from the rinds of the lemon, the orange, and the bergamotte orange, are the only ones capable of being obtained by expression, which is performed in the following manner. A small wheel, with its circumference set with short nails, is put in motion, and a lemon or orange is applied to it till the whole of the yellow outer rind is thus rasped away: the raspings fall to the bottom of the case in which the wheel turns, and when a sufficient quantity is collected, are squeezed between two plates of glass; by this gentle pressure the essential oil flows from the ruptured cells into any convenient vessel placed to receive it, and undergoes no further preparation, except that of being allowed to rest till the water and other impurities have subsided.

A method analogous to that by which the vegetable butters are obtained, is sometimes practised in India for procuring that delicious and costly perfume, the *ittur* of roses. For this purpose a clean cask, or large glazed earthen jar, is filled with rose leaves carefully separated from the calyces, and spring water poured on just sufficient to cover them: the vessel, with its contents, is then set in the sun for two or three days, and taken under cover during the night. At the end of the third or fourth day small particles of yellow oil will be seen floating on the surface of the water, which, in the course of a week, will have increased to a thin scum: this is taken up by a little cotton tied to the end of a stick, and squeezed into a small vial.

The oil contained in the fragrant blossoms of those plants which have none in their other parts, as the violet, the mignonette, the jasmine, the tuberose, the hyacinth, and all the scented liliaceous plants, &c. although exceedingly odorous, is so minute in quantity, and so easily destroyed by heat, as to be incapable of being extracted in any other way than by means of the oil of bene, as described in the last article. The fragrant oil may afterwards be separated from the oil of bene in the following manner. Let a vial be half filled with a mixture of alcohol, and perfumed oil, in equal proportions, and shaken for a few minutes, that every particle of each may come in contact with the other: then pour off the alcohol from the oil, which will be found to be nearly inodorous, having yielded its essential oil to the alcohol. Let this perfumed spirit be shaken again, with successive portions of oil, till the richness of its fragrance is not sensibly increased, and then pour it into a bason containing two or three times its bulk of pure water: the water and alcohol will combine together, and the greater part of the essential oil will be liberated, and will float at the top of the liquor, from which it may be skimmed off by means of a little cotton. The liquor being afterwards submitted to very gentle distillation, the first portion of spirit that comes over will be found to be still very fragrant, and may be employed, mixed with fresh alcohol, in treating other portions of scented oil.

By far the greater number, however, of essential oils are obtained by direct distillation. If the substance to be treated is a fresh herbaceous plant, it requires no previous treatment; but if it is a dried plant, a few hours maceration in water is advisable; if a bark or wood is to be distilled, it must be rasped or cut into shavings, and macerated for several days; this being done, a tinned copper still, or alembic is to be charged with the solid materials closely rammed down, on which is to be poured just water enough to cover them; the head being then luted on, and the refrigeratory filled with cold water, the fire must be lighted, and so regulated as to keep the contents of the still constantly simmering, but scarcely boiling. The steam being condensed in the worm will form a small stream of water, and is to be collected in proper vessels till it comes off nearly insipid and inodorous, when the distillation is to be stopped. The first part of the produce, being turbid from supersaturation with essential oil, is to be kept for some hours in a cold place, during which time the excess of oil will separate from the water, and either float on its surface, or sink to the bottom, according to its specific gravity. The complete separation of the oil from the distilled water is effected by a very simple instrument called the Italian recipient, and the whole of the water drawn off in the first distillation is to be employed, as far as it will go, in the next, instead of plain water, by which it is manifest, that the produce of oil in the second distillation will exceed that of the first, (other circumstances being equal) by all the quantity held in permanent solution by the water of the former process. Hence it is manifest, that by this mode of proceeding, the amount of oil yielded by equal quantities of the same substance, will form a constantly increasing series, till the whole of the water drawn off by each distillation is completely saturated with oil. This accounts, in some degree, for the great difference in the proportions of oil obtained by different chemists from the same plants; for as Bindheim has satisfactorily shewn, it is not till the seventh, or even, in some cases, the tenth distillation, that the produce of oil attains its *maximum*.

It is not only from the odorous vegetables themselves that essential oil may be procured, but also from such of the immediate products of vegetation as possess any odour; such are the balsams, and many of the resins and gum resins. The process to be followed is distillation with water, and precisely the same subsequent treatment as we have already described.

The peculiar odour of vegetables, when not in a state of decomposition, depending on the volatile oil that they contain, it will be obvious that the odours of the oils themselves must be equally various, and therefore incapable of being described. The taste of all of them is exceedingly hot and pungent, but in some, particularly the oil of peppermint, is followed by a remarkable sensation of coldness: this, however, is merely a nervous sensation, the thermometrical temperature undergoing no change. The acrimony of some of the oils, as the oil of cloves, is so great as actually to destroy the outer skin of the tongue and of other sensible parts. The consistence of the essential oils is very various; some being as limpid as water, while others are thick and glutinous, like the expressed oils. A slight degree of cold is sufficient for their congelation, at which time they assume the appearance of crystalline plates, which, however, must not be confounded with the prismatic crystals that most of them deposit by long exposure to the air. The colours of essential oils are various, some are blue, others green, but the usual colour is light yellow, verging more or less, by long keeping, to reddish brown.

Essential oil is completely volatile without decomposition at a heat less than that of boiling water; (hence if a few drops are spread on a piece of paper, and then held for a minute or two before the fire, any sophistication with expressed oil may be detected by the grease spot that will remain after the volatile oil has been entirely exhaled). It may, however be detained in a higher heat by mechanical mixture with dry clay or sand and then it undergoes a partial decomposition, carburetted hydrogen being given out, and a little charcoal remaining in the receiver: the undecomposed residue, if subjected three or four times successively to similar treatment, will be entirely destroyed.

Essential oils are highly combustible; they take fire on the application of an ignited body, or by the electric spark, and burn with a large white flame and a dense black smoke; a larger proportion of oxygen is required for their combustion than of the other oils, and a greater quantity of water is produced.

Oil, that by long keeping in a half-closed bottle has become thick and nearly scentless, may be rectified by re-distilling it with water, and some of the fresh vegetable from which it was originally extracted; and this was often cited as a proof that the substances called essential oils, were, in reality, compounds of resin and the *spiritus rector*, or aromatic principle. But precisely the same effect may be produced by means of alcohol, or still more readily by ether. This curious and important fact was first stated by De Roover, from whose experiments it appears, that if thick spoiled oil be mixed with one-sixteenth of sulphuric ether for a few days, and then distilled with pure water, more than half the oil will come over perfectly limpid and possessed of its peculiar odour, while the remainder will be left behind in the still in the state of a dark coloured resin. The united weights of the distilled oil and resin exceed that of the original oil, whence it is probable that the ether actually combines with part of the oil, and probably by supplying it with hydrogen, restores to it the liquidity and odour which it possessed at first. It is to be regretted that M. de R. did not follow up his experiments by treating the resinous portion with fresh quantities of ether, so as to ascertain whether it was possible to convert it in part, or entirely, into volatile oil as at first.

Essential oil is sparingly soluble in water, from which it may be separated by distillation, but is taken up much more abundantly by alcohol; this solution, however, is decomposable by water, the greatest part of the oil being separated.

TABLE.

Exhibiting the Quantity of Volatile Oil obtained from different Vegetables.

Name of the Vegetable.	*Quantity.*	*Weight of the Oil.*	*Maker of the Experiment.*
Agallochum wood	10 lb	4 drachms	Hoffmann
Angelica root	1 lb	1 drachm	Cartheuser
Aniseed	1 lb	2 drachms	Neumann
Assafœtida	4 ounces	1 drachm	
Balm, common	6 baskets	1 drachm	
—— Turkey	ditto	2 ounces	Dehne
Cajeput seeds	1 lb	15 grains	
Calamus aromaticus	50 lb	2 ounces	Hoffmann
——————	1 lb	2 scruples	Neumann
Camomile flowers, common	1 lb	1-2 drachm	Cartheuser
——————————	6 lb	5 drachms	Lewis
——————————	200 baskets	1 lb	Dehne
Camomile flowers, wild	1 lb	20 grains	Cartheuser
——————————	6 lb	2 1-2 drachms	Lewis
—————————— Roman	30 lb	1 3-4 ounces	Dehne
Caraway seeds	4 lb	2 ounces	
——————	2 lb	9 drachms	Lewis
——————	1 cwt	83 ounces	
Cardamum seeds	1 ounce	1 scruple	Neumann
Cariophilli Plinii	1-2 lb	1-2 ounce	Dehne
Carline thistle root	1 lb	2 1-2 scruples	Neumann
Carrot seeds	2 lb	1 1-2 drachm	Lewis
Cascarilla bark	1 lb	1 drachm	Cartheuser
——————	30 lb	4 ounces	Dehne
Cassia flowers	1 lb	1-2 drachm	Cartheuser
——————	30 lb	4 ounces	Dehne
Cedar wood	1 lb	2 drachms	Margraff
Chervil leaves	9 lb	1-2 drachm	Neumann
Cinnamon	1 lb	1 drachm	Sala
———	1 lb	2 1-2 scruples	Neumann
———	4 lb	6 drachms	Lemeri
———	1 lb	2 drachms	Cartheuser
———	1 lb	8 scruples	
———	3 lb	4 drachms	Dehne
Clary (garden), the seeds	4 lb	2 drachms	Lewis
—— in flower, fresh	130 lb	3 1-2 ounces	
Cloves	1 lb	1 1-2 ounce	Teichmeyer
———	1 lb	2 1-4 ounces	Cartheuser
———	2 lb	5 ounces	Hoffmann
———	2 lb	5 ounces	
———	1 lb	1 oz. 6 drach.	
———	1 lb	2 1-2 ounces	Dehne
———	1 lb	2 oz. 2 drach.	
Copaiba balsam	1 lb	6 ounces	Hoffmann
——————	1 lb	8 ounces	Lewis
Culilabana cortex	1 lb	1 drachm	Vogel
Cummin seed	1 lb	5 drachms	
——————	1 bushel	21 ounces	Lewis
Dill seed	4 lb	2 ounces	
——— with the tops	6 baskets	8 ounces	Dehne
Dittany of Crete	1 lb	30 grains	Lew's

Name of the Vegetable.	*Quantity.*	*Weight of the Oil.*	*Maker of the Experiment.*
Elecampane root	2 lb	3 1-2 scruples	Neumann
—— dry	12 lb	3 1-2 drachms	Dehne
Elemi (gum)	1 lb	1 ounce	Neumann
Fennel seed (common)	1 lb	8 scruples	
—— sweet	1 bushel	18 ounces	Lewis
Feverfew flowers	1 basket	2 drachms	Dehne
Galangal root	1 lb	1 drachm	Cartheuser
Garlic root, fresh	2 lb	30 grains	Neumann
Ginger	1 lb	1 drachm	
Horse-radish root	1 lb	15 grains	Vogel
——	8 ounces	15 grains	Neumann
Hyssop leaves	2 lb	1 1-2 drachm	
——	1 lb	ditto	Cartheuser
——	1 lb	2 drachms	
——	2 cwt	6 ounces	Lewis
——	10 lb	3 drachms	
——	30 lb	9 drachms	
Juniper berries	8 lb	3 ounces	Hoffmann
——	1 lb	3 drachms	Cartheuser
——	48 lb	6 ounces	Dehne
——	60 lb	6 3-4 ounces	
—— wood	15 lb	2 ounces	
Lavender, in flower, fresh	48 lb	12 ounces	Lewis
——	30 lb	6 3-4 ounces	
——	13 1-2 cwt	60 ounces	
——	2 lb	4 drachms	Hoffmann
—— dry	4 lb	2 ounces	Lewis
——	2 lb	1 ounce	Hoffmann
——	4 lb	3 ounces	
—— broad-leaved dry	4 lb	1 ounce	
——	1 lb	1 drachm	Cartheuser
Lovage root	1 lb	1 drachm	
Mace	1 lb	5 drachms	Neumann
Marjoram in flower, fresh	85 lb	3 3-4 ounces	Lewis
——	13 1-2 lb	3 1-2 drachms	
——	34 lb	1 1-2 ounce	
—— leaves, fresh	18 1-2 lb	1-2 ounce	
—— dry	4 lb	1 ounce	Hoffmann
Masterwort root	1 lb	1-2 drachm	Neumann
Milfoil flowers	18 baskets	4 1-2 ounces	Dehne
—— dry	14 lb	4 drachms	Lewis
Mint in flowers, fresh	6 lb	4 1-2 drachms	
—— leaves, dry	4 lb	1 1-2 ounce	Hoffmann
—— fresh	30 baskets	1 1-4 lb	Dehne
Mother of thyme	45 lb	4 drachms	
Myrrh	1 lb	2 drachms	Hoffmann
——	1 lb	3 drachms	Neumann
Nutmegs	1 lb	1 ounce	Hoffmann
——	1 lb	1 ounce	Geoffroy
——	1 lb	1-2 ounce	Neumann
——	1 lb	3-4 ounce	Sala
——	1 lb	5 drachms	Cartheuser
Parsley seeds	2 lb	1 drachm	Lewis
—— leaves, fresh	238 lb	2 ounces	
—— leaves, with the seeds	15 baskets	14 1-2 ounces	Dehne
Parsnep seeds	8 lb	2 drachms	Lewis
Pennyroyal in flower, fresh	13 lb	6 drachms	
Pepper, black	2 lb	ditto	
——	1 lb	2 1-2 drachms	Gaubius
——	1 lb	3 drachms	

Name of the Vegetable.	*Quantity.*	*Weight of the Oil.*	*Maker of the Experiment.*
Pepper, black	1 lb	2 1-2 drachms	Neumann
———	1 lb	4 scruples	Cartheuser
——— Jamaica	1 ounce	30 grains	Neumann
Peppermint, fresh	4 lb	3 drachms	Lewis
Rhodium wood	1 lb	3 drachms	Neumann
———	1 lb	2 drachms	Sala
———	1 lb	3 drachms	Sala
———	1 lb	3 drachms	Cartheuser
———	1 lb	4 drachms	Cartheuser
Roses	1 cwt	4 drachms	Tachenius
———	1 cwt	1 ounce	Homberg
———	12 lb	30 grains	Hoffmann
Rosemary, in flower	1 cwt	8 ounces	Lewis
——— leaves	1 lb	2 drachms	Sala
———	1 lb	3 drachms	Sala
———	3 lb	3 1-6 drachms	Neumann
———	1 lb	1 drachm	Lewis
——— fresh	70 lb	5 ounces	Cartheuser
Rue leaves	10 lb	2 drachms	Hoffmann
———	10 lb	4 drachms	Hoffmann
—— in flower	4 lb	1 drachm	Lewis
———	60 lb	2 1-2 ounces	Lewis
—— with the seeds	72 lb	3 ounces	Lewis
Saffron, Oriental	1 lb	5 scruples	Cartheuser
Sage leaves	34 lb	1 1-2 ounce	Lewis
—— in flower, fresh	27 lb	6 drachms	Lewis
—— of virtue, in flower	1 lb	1 1-2 drachm	Vogel
Sassafras wood	6 lb	1 3-4 ounces	Hoffmann
———	6 lb	2 ounces	Neumann
———	30 lb	7 oz. 1 drach.	Dehne
———	24 lb	9 ounces	Dehne
Savin bark	2 lb	5 ounces	Hoffmann
———	29 lb	9 ounces	Dehne
—— wood	32 lb	1-2 ounce	Dehne
Saunders yellow	1 lb	2 drachms	Cartheuser
Scurvy grass, in flower, fresh	6 baskets	6 drachms	Dehne
Smallage seeds	1 lb	10 grains	Neumann
Stæchas, in flower, fresh	5 3-4 lb	2 drachms	Lewis
Thyme, in flower, fresh	2 cwt	5 1-2 ounces	Lewis
——— dry	3 1-2 lb	1 1-2 drachm	Lewis
——— (lemon) in flower, fresh	51 lb	1 3-4 ounces	Lewis
———	98 lb	2 1-2 ounces	Lewis
——— a little dried	104 lb	3 ounces	Lewis
Wormwood leaves, dry	4 lb	1 ounce	Lewis
———	18 lb	1 1-2 ounce	Lewis
Zedoary root	1 lb	1 drachm	Neumann
———	7 lb	1 ounce	Dehne

When the quantity of oil inherent in any particular substance is to be ascertained, it cannot be done directly on the first distillation, unless water were to be employed for this purpose that is already impregnated with oil; because the water that is distilled from an oleaginous body for the first time always imbibes a considerable portion of its volatile oil, and thus renders the calculation erroneous.

Neither are vegetables impregnated with the same quantity of oil at all seasons of the year: but herbs should be applied to this purpose only when they are in full blossom, and many of them when they are run to seed. The roots are most impregnated with oil just before they send forth their radicles in the spring, but woods at the beginning of the winter. The maceration of green vegetables is needless, and indeed rather detrimental than otherwise: whereas, on the contrary, with dry and solid bodies it may be more useful, in which case some common salt is added, in order to prevent fermentation taking place. When fresh vegetables possess no particular volatile smell, it is rather of use to let them wither a little. Oils that yield a volatile odour must be distilled over with a gentle heat; but, on the other hand, such as at the same time are distinguished by a greater specific gravity, require a somewhat stronger fire for their distillation.

Most volatile oils, it is true, swim upon the water with which they have come over in distillation; there are some, however, that sink in it. The method of separating the former is, first to leave the glass filled with the oily water at rest for some days, and then, by shaking it gently, to bring the oil up to the surface of the water. It may then be taken off either with a teaspoon, or with a small glass syringe. The best method, however, is to convey it by means of a short and slender skein of cotton, from the glass in which it is first received, into another glass tied to the upper part of this, by which means, at the same time, all the impurities, which are frequently to be found in these oils, adhere to the cotton, and the oil is obtained pure and clear. With respect to the other species of these oils, which sink to the bottom in water, and are consequently heavier than water, this latter fluid must be made heavier by another body; for which purpose, nothing more is necessary to be done, than to impregnate the water strongly with common salt, till the oil which lies at the bottom of the vessel rises to the surface, whence it may then be separated in the manner above mentioned.

OILS, Vegetable Empyreumatic. Almost every vegetable matter when subjected to dry distillation, affords a quantity of oil, varying according to the nature of the substance, and the circumstances of the experiment. The oil, thus produced, has not been subjected to very accurate examination, yet may be described, as possessing the following characters. Its colour is yellowish-red, passing into blackish-red, it has a strong odour, and an acrid empyreumatic taste; it is more volatile than the fixed oils, but less so than the proper essential ones: by re-distillation with a little water, it comes over nearly colourless, and more volatile than before, though still possessed of much of its empyreumatic flavour. Two of these oils, namely, tar and birch oil, are of considerable importance; for an account of the first, we shall refer the reader to the article Turpentine. The latter is prepared in Russia, by charring birch wood in a close oven, the watery acid and oil are collected in a large receiver, and the latter product being the lightest, is skimmed off from the surface of the water. This oil has a peculiar scent, and is said to drive away worms and other insects, on which account, it is used in the dressing of Russia leather, to which it communicates those properties, that render it so much esteemed by the binders of books.

OILS, Animal, Fixed.—All animals except those included in the class of insects, contain oil; the quantity however of which, as well as the situation which it principally occupies in the body, is subject to considerable variety. In all cases it is contained in peculiar receptacles, of cellular membrane; but these receptacles in quadrupeds are for the most part but sparingly dispersed, among the muscular fibre, are more abundant in the bones, and most so of all, in the cavity of the abdomen, and especially attached to the kidneys. The hog however is an exception to this, the principal part of his fat, being deposited between the skin and the muscles. In birds, the chief seat of the oil, is immediately below the skin, and in water-fowl, it is completely secreted by a collection of glands in the rump. In the warm blooded fish, as the whale, the oil is chiefly contained in the head and jawbones, and is interposed in vast abundance, between the skin and the muscular flesh. In the cold blooded fish, it is contained in the liver, as in the shark, the cod, and the ling; or is dispersed through the whole body, as in the sprat, the herring, and pilchard.

While the fat remains in the living bo-

dy, i always in a fluid or semi-fluid state, but after it has been extracted, and is exposed to the common temperature, a remarkable difference in its consistence is observed. The oil or fat investing the kidneys of quadrupeds, is called suet or tallow, and is the most solid and hardest of any; the next in hardness, is the fat of the bones, and that in which the muscles are imbedded, is the next in degree; the fat of the hog, (called lard) is the least solid. The fat of birds is seldom so solid as hog's lard, and in many species, is actually fluid. The fat or oil of fish, is almost always fluid, at the common temperature. Besides the above varieties of animal oil, there is yet another contained in the yolk of eggs, and which may be extracted by simple pressure, after the yolk has been coagulated by heat.

Animal oil in its purest state, is obtained by cutting fresh suet into shreds, and liquefying it into boiling water, and then passing it through a piece of thin gauze, in order to separate the cellular membrane. When thus purified, it is of a yellowish-white colour, moderately hard, of a mild taste, and nearly destitute of odour or flavour: it is combustible, like the fixed vegetable oils, and agrees also with these in the changes produced upon it, by the alkalies and other chemical re-agents. All the animal oils, however, belong to the class of unctuous or fat oils, none of them being either drying in itself, or capable of becoming so, by means of litharge or other substances.

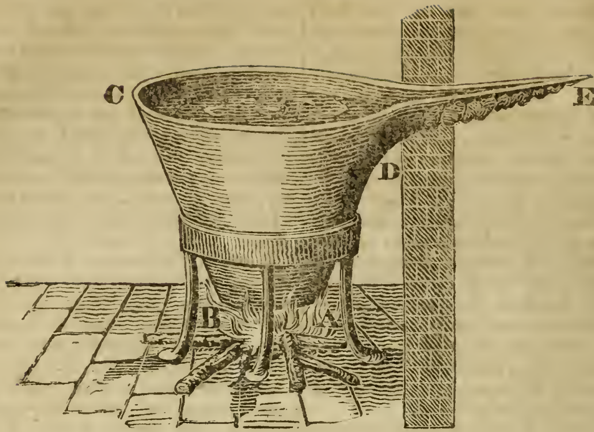
In the year 1798, a patent was granted to Mr. Collier, for a chemical process, for freeing fish-oils from their impurities, in point of smell, taste and colour; and also for improved strainers, for oils and other liquids, &c. The whole is performed in the following manner: first, the patentee pours any quantity of fish-oil, or a mixture of different kinds of oil, into a vessel, which is heated to the temperature of 110 or 120 degrees of Fahrenheit's thermometer; when a portion of caustic mineral alkali is added, the weight of which is equal to four parts to the hundred of the oil. The mixture is next agitated; and after the sediment and salt have subsided, it is drawn off into another vessel, containing a sufficient quantity of finely pulverised, fresh-burnt charcoal, and a small proportion of diluted sulphuric acid. The agitation is repeated; and, when the coal, together with the saline and aqueous particles, have subsided, the oil is passed through certain strainers. and thus rendered perfectly transparent, and fit for use. Such is the patentee's process; but as a description of the vessels employed, in edulcorating oil, would be unintelligible, without the aid of an engraving, the reader will consult the 10th volume of the *Repertory of Arts*, &c.; where the patent is fully described, and illustrated with a plate.

In April, 1792, a patent was granted to Mr. Charles Gower, for his method of depurating and improving animal oil He directs equal quantities of oil, and of water previously acidulated with a due proportion of vitriolic acid, to be poured into a barrel or other vessel, which must be placed near a fire, and briskly agitated, in order to unite the two fluids The liquor is then passed into pans, with a view to complete the solution of the gelatinous parts; and that the water may sink to the bottom; when the clear oil is decanted. Should, however, the oil intended to be purified, have a *turbid*, or *ropy* appearance, the patentee directs equal parts of such liquid and pure water, to be mixed with a little yeast, and shaken in the manner above-mentioned. When the fermentation ceases, the whole must be poured into similar pans, where all feculent particles will subside, and the oil float on the surface, whence it may be drawn off for use.

Besides its utility for lamps, animal oil possesses a valuable property, which deserves attention. If one drop be laid on a bug, fly, wasp, or earwig, it will cause the immediate death of those troublesome vermin; and, even when it is damaged, i may, according to Mr. Bucknall, be advantageously applied to fruit trees, about a month after they have been washed with soap-suds, in order to eradicate *moss*.

Vegetable oils are procured either by expression, infusion, or distillation.

Serious accidents frequently occur from vessels containing oil and other inflammable fluids boiling over, and setting fire to the surrounding buildings. To prevent these, the following form of a vessel, has been recommended by the late T. P. Smith, in the *Transactions of the American Philosophical Society*: vol. 4.



Let A B C D, represent a large Kettle; D E, a spout running out to the distance of three or four feet, commencing at D, four or five inches from the brim of the kettle, and the termination of it E, just as high as the brim, C. Let the bottom of this spout be covered with wet sponges, or rags. Now, suppose the kettle to be filled up to D, with any fluid, then as soon as it commenced boiling, it would rise in the kettle, and in rising but a small perpendicular height, would pass a considerable distance up the spout D E; here the liquor would soon cool, and of consequence fall back into the kettle, and the whole subside to its original height. This would occur as often as the fluid rose above D, as the evaporation from the wet sponges or rags, would keep D E constantly cool. It would perhaps be best to pass the spout, through the side of the building into the open air, as thereby the evaporation would be increased, and consequently the spout kept at a lower temperature; in this case it might be covered.

In case of the fluid to be boiled possessing a very strong elective attraction to caloric, (matter of heat,) the spout may be extended to the width of the diameter of the kettle, or a projecting shelf might be formed all around it, lined below with wet sponges or rags.

Animal oils, are substances of great economical importance. They are used as food, and in medicine, as the base of various unguents: they are largely employed in the manufacture of soap, and for burning either in lamps, or in the form of candles.

OIL, Animal, Volatile, or Dippel's oil.—As in the vegetable kingdom, oil is produced by the destructive distillation of various substances, that contain none in their natural state; so it is with respect to the animal kingdom. If albumen, or gluten be distilled at a dry heat, there arises together with the ammonia, and carburetted hydrogen, a quantity of fetid black oil; this was made the subject of various experiments, first by Dippel, a chemist of Berlin, and afterwards by Rouelle. From the concurrent labours of these enquirers it appears, that if this oil is rectified by three successive distillations from the surface of the water, or by a greater number without water, it becomes at length, quite colourless and transparent; it has a powerful, but somewhat aromatic odour, and is nearly as light and volatile as ether. It contains a little ammonia, and hence changes the colour of syrup of violets, green; it is sparingly soluble in water, and largely so in oils, ether, and alcohol. It combines both with acids and alkalies, into imperfect soaps; it is very inflammable, and like the vegetable essential oils, may be set on fire by strong nitrous acid. If exposed to the light, it is partly decomposed, losing its transparency, and becoming of a brown colour. It was formerly employed in medicine, but is now wholly disused.

OIL Mineral, or *Petroleum*. See Bitumen.

OIL of Vitriol. See Sulphuric Acid.

OIL-COLOUR CAKES. The greatest silver Pallet and twenty guineas were voted to Mr. Blackman, for discovering to the Society, for the use of the public, his method of making the above mentioned cakes.

Take of the clearest gum mastich, re-

duced to fine powder, four ounces; of spirit of turpentine, one pint; mix them together in a bottle, stirring them frequently till the mastich is dissolved; if it is wanted in haste, some heat may be applied, but the solution is best when made cold. Let the colours to be made use of, be the best that can be procured, taking care that, by washing, &c. they are brought to the greatest degree of fineness possible. When the colours are dry, grind them on a hard close stone, (porphyry is the best) in spirit of turpentine, adding a small quantity of the mastich varnish. Let the colours so ground become again dry; then prepare the composition for forming them into cakes, in the following manner. Procure some of the purest and whitest spermaceti, you can obtain; melt it over a gentle fire, in a clean earthen vessel; when fluid, add to it one-third of its weight of pure poppy oil, and stir the whole together; these things being in readiness, place the stone, on which your colours were ground, on a frame or support, and, by means of a charcoal fire under it, make the stone warm; next grind your colour fine with a muller; then, adding a sufficient quantity of the mixture of poppy oil, and spermaceti, work the whole together with a muller, to a proper consistence; take then a piece, of a fit size for the cake you intend to make, roll it into a ball, put it into a mould, press it, and it will be complete.

When these cakes are to be used, they must be rubbed down in poppy or other oil, or in a mixture of spirit of turpentine and oil, as may best suit the convenience or intention of the artist.

N. B. It may be proper to observe, that Mr. Blackman's colours in bladders, are prepared with a mixture of spermaceti, and differ from his cakes, only in having a larger proportion of oil.

At the end of the foregoing description, are testimonies from Mr. Cosway, Mr. Stothard, and Mr. Abbot; stating that Mr. Blackman's oil-colour cakes, work as well as other oil-colours; that their drying without a skin upon the surface, is a great advantage; and that Mr. Blackman's invention is, upon the whole, an essential improvement in oil painting.

OIL, OLIVE. See Oil.

ONION. See Agriculture, and Kitchen Garden.

OPIUM. On wounding the heads or stalks of the white poppy, a milky juice exudes; which exsiccated, proves a fine kind of opium. In Natolia, Cilicia, Cappadocia, in the neighbourhood of Cairo, and in several parts of the Turkish dominions, poppies are cultivated for this use in fields, as corn among us. This method of collecting the juice by incision, is described by Kæmpfer, in his Amœnitates Exoticæ. This process, however, is now but rarely practised, the consumption of this drug, being too great to be supplied by that method of collection. The best sort of the officinal opium, is the expressed juice of the heads, or of the heads and the upper part of the stalks, inspissated by a gentle heat: this was formerly called meconium, in distinction from the true opium, or juice which issues spontaneously. The inferior sorts, (for we find considerable differences, in the quality of this drug,) are said to be prepared by boiling the plant in water, and evaporating the strained decoction; but as no kind of our opium will totally dissolve in water, the juice is most probably extracted by expression. Neumann was informed, by some Turks at Genoa and Leghorn, that in some places the heads, stalks, and leaves are committed to the press together, and this juice inspissated affords a very good opium.

On this head Dr. Lewis remarks, that the point has not yet been fully determined. It is commonly supposed, that, whatever preparations the Turks may make, from the poppy for their own use, the opium brought to us, is really the milky juice, collected from incisions made in the heads, as described by Kæmpfer. It is certain, that an extract made by boiling the heads, or the heads and stalks, in water, is much weaker than opium; but it appears also, that the pure milky tears are considerably stronger.

The principles separable from opium, are, a resin, gum, a minute portion of saline matter, water, and earth. The resin is of two kinds; one more truly resinous, of a solid consistence, in its nature more fixed, and its operation more sluggish; the other softer and thinner, more volatile, and of much more speedy and powerful activity. The saline matter is of the acidulous kind, analogous to the essential salts of other vegetables: its proportion is so small, that it is not easily separable in its proper form, though it has sometimes happened, that actual crystals have concreted in a watery solution of opium. The resin, the gum, and the salt, are very intimately combined together, insomuch that all the three dissolve almost equally in water, and in spirit: it is probably to the saline principle in this and other vegetables, that this intimacy of union, is in great measure to be ascribed.

Four ounces of opium, treated with alcohol, yielded three ounces and four scruples of resinous extract, five drachms and

a scruple of indissoluble impurities remaining. On taking four ounces more, and applying water at first, Neumann obtained two ounces five drachms and one scruple, of gummy extract; and, by digesting the residuum in alcohol, three drachms and one scruple of resinous extract; the indissoluble part amounting here to seven drachms and a scruple. In distillation, alcohol brought over little or nothing; but the distilled water was considerably impregnated with the particular ill smell of the opium.

The subtile soft kind of resinous matter dicovers itself in great measure, in the bare watery solution of opium, generally rising to the surface in form of a fat, unctuous, frothy substance. This is the strongest and most active part of the opium; a few grains are sufficient to kill a dog, who could bear a whole drachm of crude opium. From a pound of opium, we may collect two or three drachms of this balsam-like substance; but we are not to imagine, that this is the whole quantity, which the opium contains: beside what thus spontaneously separates, a part remains combined with the rest of the juice, and probably is the principle, or the direct seat of the principle, that gives activity to the whole

As opium in substance is frequently found to be productive of unfavourable consequences, different methods have been contrived for correcting or rendering it more universally safe, but none have produced a medicine better, than the pure opium itself.

Opium has been made from poppies equal to that imported from abroad: and Doctor Coxe of Philadelphia, asserts, that the inspissated milky juice of the common garden lettuce, is precisely similar in its effects, to the opium from Turkey. The reverend Mr. Cartwright too, is said to have found the same thing. Opium has been made in the United States.

The following experiments, on the cultivation of the poppy plant, and the method of procuring opium, &c. by Dr. Shadrach Ricketson, of Dutchess county, New York; taken from the American Magazine published in New York, may be useful in addition.

Opium is the produce of the *papaver somniferum* of Linnæus, which, as a *genus* comprehends two species, viz. 1. The double; 2. The single; each of which includes several varieties, as to the colour of the flowers, some being white, some red, others purple and variegated.

From history we are told, that in the several provinces of Asia, it is the large white poppy only, that is cultivated for the purpose of collecting opium; but from the trials I have made, I am of opinion that it is a matter of indifference, which species or variety of the plant is cultivated, for the purpose of collecting opium; as they all afford, when tapped, a juice that is similar as to quantity, colour, and every other respect, both fresh, and when dried; however, I have thought that the large double species, produces the greatest number of heads, and consequently the greatest quantity of juice from one seed; but of this, I have not yet had sufficient trials to be certain.

Among the poppies cultivated, with a view to make the present experiments, I had some that had thirty heads apiece, all of which sprung from one seed, and from one original stock.

The poppy seeds in this country, should be sown or planted, about the middle of May, in rich, moist ground.

The ground should be formed into areas of about four feet in width. The seeds should be planted, at about ten or twelve inches distance, in transverse rows, which should always be about the same distance from each other.

Shallow holes, of an inch depth, should be made in the rows, at the distance mentioned: the seeds put in, and covered over even with the ground; after which they are suffered to remain, till the plants are grown about four inches high, when, especially if the land is dry and not fertile, they may be frequently watered and manured, the best kind for which last purpose, is said to be a compost of ashes, dung, and a nitrous earth.

They are said, in the East-Indies, to water them again profusely, just before the flowers appear; but as I have had them grow very luxuriant and succulent, in good ground, without either manuring or watering, I am disposed to think, that the advantages arising from this last particular, are not equal to the trouble of doing it.

It is scarcely necessary to remark, that the plants, at their first coming up, should be kept clean from weeds, and the like, which may be done with very little trouble, with a small hoe, especially if the seeds are planted after the manner I directed, that is, in rows.

Having said all that is necessary, on the cultivation of the plant, I shall now proceed to describe the method of obtaining its juice, which, when inspissated to a pilular consistence is called opium.

The states of the plants, wherein I have

found them to yield more juice, are just before, in the time of, and immediately after flowering, the plants being arrived to one or the other of the states above mentioned.

We then proceed to that part of the process, called tapping, which we are told is done in Asia, by making two or three longitudinal incisions, in the half grown capsules, without penetrating their cavities at sunset, and the plants suffered to remain till morning, when the juice is to be scraped off, and worked in a proper vessel, in a moderate heat, till it becomes of a pilular consistence; which method, with several others, I have tried, but none have succeeded so well with me as, in a sun-shining day, to cut off the stocks at about an inch distance from their flowers or capsules, and as soon as the juice appears, which it does at first equally well on the part of the stalk cut off with the capsule or flower as on the standing part, to collect it with a small scoop or penknife, the last of which I have found to answer the purpose very well. After the juice ceases to appear on the top of the standing stalk, it should be cut off about an inch lower, when it will be found to yield almost as freely as before, and repeated as long as the juice appears.

The juice, when collected, should be put into an evaporating pan, placed in the sun's heat, and frequently stirred till it becomes of a consistence to form into pills, or made into rolls, for keeping or transportation.

The quantity of opium that may be procured, depends very much on the largeness of our plants, and the care used in collecting it.

ORANGE.—The flowers of orange trees afford, by distillation, a very fragrant essential oil. From the rind of the fruit an essential oil may be obtained by expression. The juice of the fruit contains an essential acid salt, mixed with much mucilage. This salt may be obtained in crystals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The oil may be obtained by expression.

The Orange-tree is divided into several varieties, of which the most esteemed are those of *China* and *Seville:* it is seldom raised, excepting in the hot-houses of the curious; and, its culture being the same as that of Citron, we refer the reader to that article.

The *flowers* of the orange-tree are highly esteemed, on account of their odoriferous perfume: they are of a slightly pungent, bitter taste, and communicate their flavour, by infusion, to rectified spirit; and also, by distillation, both to spirit and water. Formerly they were in great repute, on account of their supposed efficacy in convulsive and epileptic cases, though later experience has not confirmed these advantages—similar virtues have been attributed to the *leaves,* which have likewise been found ineffectual in those complaints.

The juice of oranges is a pleasant subacid liquor, which has often proved of service in inflammatory or febrile disorders; by diminishing heat, allaying thirst, and promoting the salutary discharges. It is likewise eminently useful in the scurvy, and has, therefore, been introduced into the navy, as part of the stores of ships destined for long voyages.

Nor is the outer rind less valuable, as it forms the basis of an excellent conserve; and, when preserved with sugar, is deservedly esteemed in desserts, being a grateful aromatic bitter, and one of the best stomachics.—There is also an oil expressed from the orange-peel, which is sold under the name of *Bergamot.*

From the flowers of this tree, an essential oil is prepared in Portugal and Italy, termed *Essentia Neroli:* this perfume is said to possess a more delicate and agreeable fragrance than even the *Ittur of Roses*; but it is with difficulty procured.

Lastly, the Seville, or *Bitter Orange,* is seldom employed in medicine at present; the China orange being generally substituted.

ORANGE WINE.—Mr. Johnson has given the following recipe for this liquor.

Take the expressed juice of eight Seville (sour) oranges, and having one gallon of water wherein 3 lbs. of sugar have been dissolved, boil the water and sugar for 20 minutes; skim constantly, and when cooled to a proper heat for fermentation, add the juice and the outer rind of the orange thinly shaved off, and putting all into a barrel, let it be frequently stirred for two or three days, and then close bunged for six months or longer before bottling.

ORCHAL, or Cudbear, of some, is the *Lichen Roccella* of Linnæus, used in dyeing. See Dyeing.

ORE.—In presenting our readers with the following observations, we intended to have embraced a catalogue of sundry American ores; but, owing to our information being confined, from the little which is known on the subject, we have to remark, in a general way, that the ores

of metals are found, almost all, within, or in the neighbourhood of, the United States : as to stating their locality, it would be impossible to do so, in order to render the information connected. A work of this kind has already been attempted (and is now progressing) by Dr. Bruce, professor of mineralogy, New-York; at the conclusion of which, a valuable fund of information will be presented to the American public. Whatever has appeared heretofore is imperfect, and by no means conclusive.

In noticing the ores of metals, the subject of reduction, &c. has been considered as a proper place in which every information, although probably given before, may be considered. The length of the article, for which we are principally indebted to Nicholson, is therefore obvious.

Ores are native substances, containing the metals in an altered state, in all cases, either combined with some foreign substance, which deprives them of malleability and metallic brilliancy, or else so intimately mixed, that the particles of metal cannot be discerned. In all cases wherein the metallic substance is clearly distinguishable, it is not called an ore, but a native metal.

The metal in most ores is in the state of an oxide. When ores contain nothing but the oxide of the metal with the addition of more or less carbonic acid, they were formerly said to be calciform; but when they are combined with other substances, they were said to be mineralized. The mineralizers are either arsenic or sulphur. Beside the mineralizers, there are various stony matters, which accompany ores in a certain peculiar way, with regard to crystallization and appearance; which has occasioned miners to consider them as possessing an affinity to the ore. This stony accompaniment, of which a better notion may be formed by inspection of ores than from any general description, is called the matrix of the ore. The rocks that lie over the veins are called the roof; those that lie under them, the floor, and by some the hading. The matrix is almost always a finer species of stone than the surrounding rocks, though of the same genus. Even the rocks themselves are of a finer grain as they approach the vein. There is no matrix peculiarly appropriated to any metal: it has only been remarked, that tin is generally found among stones of the siliceous genus, and lead very frequently among those of the calcareous. See METALLURGY, and the several metals.

Ores therefore consist, 1. of metallic substances in the state of oxide; or, 2. of these substances combined with other matters, with which they are said to be mineralized.

Mineralized ores are—1. Simple, containing only one metallic substance; or, 2. Compound, containing two or more metallic substances.

Of the simple, and also of the compound ores, four kinds may be distinguished:

1. Ores consisting of metallic substances mineralized by sulphur, or sulphurets. Such is the lead ore, called galena, composed of lead and sulphur.

2. Ores consisting of metallic substances mineralized by arsenic. Such is the white pyrites, containing iron and arsenic.

3. Ores consisting of metallic substances mineralized by sulphur and by arsenic. Such is the ruby silver ore, containing silver, arsenic, and sulphur.

4. Ores consisting of metallic substances mineralized by saline matters. Such is the native sulphats. Such also is the corneous silver ore, which is silver combined with muriatic acid. To this class also may be referred the silver mineralized by an alkaline substance, which Mr. Von Justi says he has discovered.

Henckel, and after him Cramer and Macquer, affirm, that in mineralized ores, beside the above-mentioned metallic and mineralizing substances, are also contained a metallic and an unmetallic earth. But Wallerius affirms, that the existence of such earths cannot be shown, and that sulphur is incapable of dissolving unmetallic earths, and even the oxides of all metallic substances, excepting those of lead, bismuth, and nickel.

Metals and metalliferous ores are found in various places.

I. They are found under water, in beds of rivers, lakes, and seas, and chiefly at the flexures of these: such are the auriferous and ferruginous sands, grains of native gold, ochres, and fragments of ores washed from mines.

II. They are found dissolved in water: such are the mineral waters containing sulphats of iron, copper, or zinc.

III. They are found upon the surface of the earth. Such are many ochres; metalliferous stones, sands, and clays; and lumps of ore. Mr. Gmelin says, that in the northern parts of Asia ores are almost always found upon or near the surface of the ground.

IV. They are found under the surface of the earth. When the quantity of these

collected in one place is considerable, it is called a mine.

Subterranean metals and ores are differently disposed in different places.

1. Some are infixed in stones and earths, forming nodules or spots diversely coloured.

2. Some are equally and uniformly diffused through the substance of earths and stones, to which they give colour, density, and other properties. Such are the greatest part of those earths, stones, sands, clays, crystals, flints, gems, and spars, which are coloured.

3. Some form strata in mountains. Such are the slates containing pyrites, copper ore, lead ore, silver ore, or blend. These lie in the same direction as the strata of stones, betwixt which they are placed; but they differ from the ordinary strata in this circumstance, that the thickness of different parts of the same metalliferous stratum is often very various; whereas the thickness of the stony strata is known to be generally very uniform.

4. Fragments of ores are frequently found accumulated in certain subterranean cavities, in fissures of mountains, or interposed betwixt the strata of the earth. These are loose, unconnected, frequently involved in clay, and not adherent to the contiguous rocks or strata immediately, or by intervention of spar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here described.

5. Large entire masses of ores are sometimes found in the stony strata of mountains. These are improperly called cumulated veins, because their length relatively to their breadth and depth is not considerable.

6. Some instances are mentioned of entire mountains consisting of ore. Such is the mountain Taberg, in Smoland; and such are the mountains of Kerunavara and Luosavara, in Lapland, the former of which is 1400 perches long, and 100 perches broad. These mountains consist of iron ore.

7. Lastly, and chiefly, metals and ores are found in oblong tracts, forming masses called veins, which lie in the stony strata composing mountains.

The direction of veins greatly varies, some being straight and others curved. Their position also respecting the horizon is very various; some being perpendicular, some horizontal, and the rest being of the intermediate degrees of declivity.

The dimensions, the quality, and the quantity of contents, and many other circumstances of veins, are also very various. Miners distinguish the several kinds of veins by names expressive of their differences. Thus veins are said to be deep; perpendicular; horizontal, or hanging, or dilated; rich; poor; morning, noon, evening, and night veins, by which their direction toward that point of the compass where the sun is at any of these divisions of the natural day, is signified.

Some parts of veins are considerably thicker than others. Small veins frequently branch out from large veins, and sometimes these branches return into the trunk from which they issued. These veins, from which many smaller veins depart, have been observed to be generally rich.

Veins are variously terminated: 1. by a gradual diminution, as if they had been compressed, while yet soft, by superincumbent weight, or by splitting and dividing into several smaller veins: or, 2. they are terminated abruptly, together with their proper strata in which they lie.

This abrupt termination of veins and strata is occasioned by their being crossed by new strata running transversely to the direction of the former; or by perpendicular fissures through the strata; which fissures are frequently filled with alluvial matters, or with water, or are empty. These perpendicular fissures seem to have been occasioned by some rupture or derangement of the stratum through which the vein passes, by which one part of it has been raised or depressed, or removed aside by the other, probably by earthquakes. Where the vein is terminated abruptly, it does not cease, and is only broken and disjoined; and is often recovered by searching in the analagous parts of the opposite side of the deranged stratum. A principal part of the art of miners consists in discovering the modes of their derangements from external marks, that they may know where to search for the disjoined vein.

The contents of veins are metals and metalliferous minerals, as the several kinds of ores, pyrites, blends, guhrs; the several kinds of spars, quartz, horn-blend, in which the ores are generally imbedded, or enveloped, and which compose the matrix of the ore; stalactites; crystallizations of these metalliferous and stony substances, encrusting the small cavities of the circumjacent rock; and lastly, water, which flows or drops through crevices in that rock.

In a vein, ores are found sometimes attached to the rock or stratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and sometimes both these kinds of adhe-

sion occur in the same vein at different places. Frequently between the matrix and the rock a thin crust of stone, or of earth, is interposed, called by authors the fimbria of the ore.

The matrix, or the stone in which the ore lies enveloped, is of various kinds in different veins. And some kinds of stone seem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, spar, fluats, and horn-blend, give reception to all ores and metals, but slates chiefly to copper and silver, and never to tin; calcareous and sparry matrices, to lead, silver, and tin; and mica to iron.

Veins lie in strata of different kinds of stone; but more frequently in some kinds of stone than in others. Thus, of the simple or uncompounded stones which compose strata, the following are metalliferous: calcareous stones; slaty sand stone; feltspar; quartz, sometimes jasper, frequently slates, and chiefly micaceous or talky stones, and horn-blend. No veins have been found in gypseous or siliceous strata, though cherts and flints frequently contain metallic particles, and some instances have been observed of ores of silver and tin in alabaster. Of compound stones, those are said to be chiefly metalliferous, which consist of particles of horn-blend. Veins have also been found in the red granite; but seldom, if ever, in any other granite, or in porphyry. In general, veins are more frequently found in soft fissile, and friable strata, than in those which are compact and hard.

A vein sometimes passes from one stratum into the inferior contiguous stratum. Sometimes even the veins of one stratum do so correspond with those of an inferior stratum, the contiguity of which with the former is interrupted by a mass of different matter, through which the veins do not pass, that they seem originally to have been continued from one stratum to the other.

Thus, in the mines of Derbyshire, where the veins lie in strata of lime-stone, the contiguity of which strata with each other is interrupted in some places by a blue marl or clay, and in other places by a compound stone called toadstone, the veins of one stratum frequently correspond with the veins of the inferior stratum of lime-stone; but are never continued through the interposed clay or toadstone. But we must observe, that these interposed masses, the blue marl, clay, and toadstone, have not the uniform thickness, observable in regular strata, but are (especially the toadstone) in some places a few feet in depth, and in others some hundreds of yards.

The above disposition seems to indicate, that these several strata of limestone have been originally contiguous; that the veins now disjoined have been once continued; that these strata of limestone have been afterward separated by some violent cause, probably by the same earthquakes which have in a singular manner shattered the strata of this mountainous country; that the interstices thus formed between the separated strata have been filled with such matters as the waters could insinuate, probably with the mixed comminuted ruins of shattered strata; or with the lava of neighbouring volcanoes, of which many vestiges remain.

To the above historical sketch of mines it may not be improper to add some conjectural remarks concerning their formation.

Those ores which are found under water (I); upon the surface of the earth (III); in fissures of mountains and subterranean cavities, accumulated, but not adherent to the contiguous rocks (IV); seem from their loose, unconnected, broken appearances to have been conveyed by alluvion.

All martial ochres have probably been separated from ferruginous waters (II), either spontaneously, or by calcareous earth; and these waters seem to have acquired their metallic contents by dissolving the sulphat which is produced by the spontaneous decomposition of martial pyrites. The ochres of copper, zinc, and, perhaps, of several other metals, have probably been precipitated from waters containing their sulphats by some substance, as calcareous earth, more disposed to combine with acids; and these waters have probably been rendered metalliferous, by dissolving the sulphats produced by a combustion of cupreous pyrites, and of the ore of zinc called blend; for these minerals are not, as martial pyrites is, susceptible of decomposition spontaneously, that is, by air and moisture.

The metalliferous nodules and spots (IV, 1,) seem to have been infixed in stones while these were yet soft. Perhaps the metalliferous and lapideous particles were at once dissolved and suspended in the same aqueous menstruum, and during their concretion crystallized distinctly, as different salts do when dissolved in the same fluid.

The earths and stones uniformly coloured by metals (IV, 2,) were also probably in a soft state while they received those tinges. The opake coloured stones

seem to have received their colour from metallic oxides mixed and diffused through the soft lapideous substance; and the transparent coloured stones have probably received their colours from salts, or from metallic particles dissolved in the same water, which softened or liquefied the stony substance; which metallic salts and particles were so much diffused, that they could not be distinctly crystallized. That all stones have been once liquid and dissolved in water appears probable, not only from their regular crystallized forms, but also from the solubility of some stones, as of gypseous and calcareous earths, in water; and from the water which we know is contained in the hardest marbles, as well as in alabasters; to which water these stones owe the crystallization of their particles.

The veins called cumulated (IV, 5,) and the entire metalliferous mountains (IV, 6,) are believed by Wallerius to be analogous to the nodules (IV, 1,). These metalliferous substances seem to have been originally formed or concreted in the places where they are found.

The metalliferous strata (IV, 3,) have probably been insinuated between the lapideous strata, after the separation of these from each other by some violent cause; in the same manner in which it was supposed, that the clay and toadstone have been insinuated betwixt the several strata of limestone in Derbyshire. The matters thus insinuated may have been either fluid, which would afterward crystallize, and form entire regular masses; or they may have been the ruins of shattered strata, and veins brought by waters, and there deposited: in which case they will appear broken and irregular. The metalliferous strata, though frequently confounded with the horizontal or dilated veins, may be distinguished, according to Wallerius, from these, by the following properties:—

1. They are generally thinner and much broader than the veins called dilated.

2. They are seldom found at a greater depth than 100 perches, and generally in the neighbourhood of veins, from which they probably have received their contents.

3. From their want of the thin incrustations called fimbriæ, which, as has been observed, are frequently interposed betwixt the rock and the ore, or its matrix; and from their want of the other properties of veins.

But in veins, properly so called, the strongest marks exist of ores having been there concreted, and not carried thither and deposited in their present state. Their regular, unbroken appearance, their adhesion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix enveloping the ore, the frequent crystallization of the ore, and of the other contents of the vein, indicate that ores, as well as the other solid contents, have been there concreted from a fluid to a solid state.

Most authors believe, that veins, and the perpendicular clefts in the stony strata of mountains, called fissures, have been produced by the same cause; or, rather, they consider veins only as fissures filled with metalliferous matters. They farther believe, that fissures have been occasioned by the exsiccation of strata, while these were passing from a fluid to a solid state. Wallerius imagines, that fissures have been formed from exsiccation; but that veins were channels made through the strata, while yet soft and fluid, by water, or by the more fluid parts of the strata, penetrating and forcing a passage through the more solid parts. He conceives, that these fluid parts conveyed thither their metalliferous and stony contents, which were then coagulated or concreted. He supports his opinion by observing, that all the veins of the same stratum generally run parallel to each other; that they frequently bend in their course; that the same vein is sometimes contracted and sometimes dilated; that veins are frequently terminated by being split or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fissures are always widest at top, and are very narrow below; all which appearances, he thinks, could not have been produced by exsiccation.

From these reasons, fissures appear to have had a different, and from the disjunction and rupture of veins crossed by fissures, they seem to have had a later origin than veins. Whether fissures could have been produced by the very gradual exsiccation of these large masses, or strongly coherent matter; or whether they have been produced by the same violent causes, namely, earthquakes; by which the strata in which fissures are generally found, have been broken and deranged, and by which metalliferous mountains themselves have been formed, or their strata raised above their original level, as some others have with great probability conjectured, cannot with certainty be determined.

Veins are seldom, if ever, found but in mountains: the reason of which may not improbably be, that in metalliferous mountains we have access to the more ancient strata of the earth, which in plains are

covered with so many deposited, alluvial, and other later strata, that we can seldom if ever reach the former. That these mountains consist of strata which have been originally lower than the upper strata of adjacent plains, appears from an observation which has been made, that the strata of mountainous countries dip with more or less declivity as they approach the plains, till they gradually sink under the several strata of those plains, and are at last immersed beyond the reach of miners. This leading fact in the natural history of the earth has been observed by a sagacious philosopher Mr. Mitchell, in his Conjectures concerning Earthquakes, &c. Philos. Trans. 1760.

That the inferior strata of the earth contain large quantities of pyritous, sulphurous, and metalliferous matters, appears,

1. From the subterranean fires in those inferior strata, which produce volcanoes, and probably earthquakes (as Mr. Mitchell ingeniously conjectures).

2. From the observation, that all kinds of mountains are not equally metalliferous; but that veins, especially, are only found in those mountains, which, being composed of very ancient strata, are called primeval; which form the chains and extensive ridges on the surface of the earth, which direct the course of the waters, and which consist of certain strata, the thickness of each of which, its genuine qualities, and its position relatively to the other strata, are, in different parts of the chain of mountains where that stratum is found, nearly uniform and alike, notwithstanding that the numbers, and the inclinations of the strata composing contiguous mountains, or even different parts of the same mountain, are often very various; and, therefore, that veins are seldom, if ever, found in the mountains called by authors alluvial and temporary, which are single, or detached, which consist not of strata uniformly disposed, but of alluvial masses in which fragments of ores may be sometimes, but veins never, found. Nevertheless, single, and seemingly detached, mountains in small islands have sometimes been found to be metalliferous. But we must observe, that these mountains consist of uniform strata; that islands themselves, especially small islands, may be considered as eminent parts of submarine ranges of mountains; and that the mountains of such islands may be considered as apices or tops only of inferior mountains.

Those mountains are said to be most metalliferous which have a gentle ascent, a moderate height, and a broad basis, the strata of which are nearly horizontal, and not much broken and disjoined. In these mountains, at least, the veins are less interrupted, more extended, and consequently more valuable to miners, than the veins in lofty, scraggy, irregular and shattered mountains.

Authors dispute concerning the time in which ores have been formed, some referring it to the creation of the world, or to the first subsequent ages; and others believing that they have been gradually from all times, and are now daily forming. From the accretion of ores and of their matrices to their proper rocks, and from the insertion of metalliferous nodules and striæ in the hardest stones, it seems most probable, that the matter of those veins and nodules is nearly coeval with the rocks and stones in which they are enveloped.

Nevertheless, it cannot be doubted but that small quantities, at least, of ores, are still daily formed in veins, fissures, and other subterranean cavities. Several well attested instances confirming this opinion are adduced by authors: Cronstedt mentions an incrustation of silver ore, that was found adhering to a thin coat of lamp black, or of soot, with which the smoke of a torch had soiled a rock in a mine at Koningsberg, in Norway; and that this incrustation of silver ore has been formed by a metalliferous water passing over the rock. Lehman affirms, that he possesses some silver ore attached to the step of a ladder, found in a mine in the Hartz, which had been abandoned two hundred years ago; and that several steps of ladders similarly incrusted had been found. Many other instances are mentioned by authors, of galena, pyrites, silver ores, and other metalliferous substances having been found adhering to wood, to fossil-coal, to stalactitical incrustations, to oyster-shells, and other recent substances.

From these, and from similar instances, it seems probable, that not only ochres and fragments of ores may, with other alluvial matters, be now daily deposited, but also that small quantities of mineralized ores are recently formed; although many histories mentioned by Becker, Barba, Henckel, and other authors, of the entire renovation of exhausted veins, and especially those of the growth and vegetation of metals and of ores, appear to be at least doubtful.

Various opinions have been published concerning the formation of mineralized ores. According to some, these ores were formed by congelation of the fluid masses found in mines, called gurhs. Other au-

thors believe, that ores have been formed by the condensation of certain mineral, metallic, sulphureous, and arsenical vapours, with which they suppose that mines abound. Some have even affirmed, that they have seen this vapour condense, and become in a few days changed into gold, silver, and other metallic matters.

It has been above observed, that, from several appearances which occur in veins, there is great reason to believe, that ores have not been carried thither and deposited in their present state, but have been there concreted and crystallized; that is, changed from a fluid to a solid state. But the fluidity of the metalliferous matters at the time of their entrance into veins may have been occasioned either by their having been dissolved in water, if they were capable of such solution, or by their having been raised in form of vapour by subterranean fires. For the disposition to crystallize is acquired by every homogeneous substance that is fluid, whether it have received its fluidity by being melted by fire, or by being dissolved in a liquid menstruum, or by being reduced to the state of vapour. Thus, crystals of sulphur have been observed to be daily formed by the sulphureous vapours which exhale in the neighbourhood of volcanoes.

The volatility of the two mineralizing substances, sulphur and arsenic, and the power which volatile bodies possess of elevating a certain portion of any fixed matter which happens to be united with them, render it probable, that the greatest part at least of mineralized ores have been formed of vapours exhaled from subterranean fires through the cracks in the intervening strata, occasioned by those earthquakes which have in a singular manner broken and deranged the strata of metalliferous countries, and which, as has been above remarked, have been probably occasioned by, at least have certainly been always accompanied with, subterraneous fire.

Description of a Machine for raising Ore from Mines By Mr. T. Arkwright, *of Kendal, Westmoreland, (England.)*

A, Plate XII. fig. 5, is an endless chain formed of thin plates of iron, through the ends of which plates iron bolts are passed, which keep the sides of the chain at a certain distance asunder, and on which the buckets to contain the ore are suspended, B C D E, the buckets suspended on the iron bolts, G H I, three cylinders, round which the chain and buckets revolve. The two cylinders G H are placed above the shaft; the cylinder I within the mine. Their rims are so much higher than the body of the cylinders, as to admit the buckets to lie within the rims.

As the endless chain and buckets are moved forwards by a power applied to the axis of the cylinder G, the bolts of the chain fall into notches made at regular distances in the rims of that cylinder, which preserve the chain from slipping.

As each empty bucket passes under the axis of the bottom cylinder I, it loads itself with ore instantaneously from a box K, constantly filling by the workmen below, which box rests on two moveable pins L, at that end furthest from the wheel, and on an iron ketch M at the other. The bucket thus filled ascends to the top of the cylinder G: and, in its passage betwixt the cylinders G and H, discharges its contents into a channel or receiver placed betwixt them, from whence they slide into a cart or receptacle placed underneath the inclined trough N. The empty bucket passes over the cylinder H, descends on the opposite side under the cylinder I, and loads itself again at K, as before mentioned; the buckets regularly loading and discharging themselves, whilst the cylinder G is kept in motion.

O is a racket-wheel on the cylinder, to prevent a retrograde motion in the chain.

Fig. 2, shews, upon a large scale, the manner in which the box K above mentioned loads the buckets. P is an iron tooth projecting from the endless chain, which, pressing upon the catch R, underneath the box K, occasions that part of the box next the chain to sink down, and discharge into the bucket beneath it a quantity of ore sufficient to fill it. As the loaded bucket rises, it lifts the box K to its former place, till the operation is repeated by the next tooth upon the chain.

Ores of Antimony.

Dr. Bruce observes, that in recently examining some mineral productions from Louisiana, he was much gratified in observing several very rich specimens of this highly valuable metal. Antimony is at present in so much demand, that our type-founders, in consequence of the difficulty of obtaining it from Europe, have for some time past been nearly at a stand. From the assurance that this ore occurs in very considerable quantities, we are in hopes that such will be the supply, that our types ere long, will be manufactured entirely from American materials.

Antimony has been found in the native state of a silver colour, and its texture composed of moderately large, shining plates. It has the same habitudes in acids,

as the metal reduced from the sulphuret, and aqua regia more particularly dissolves it very well. The solution does not lose its transparency in the cold. Alkalis throw down a white precipitate. The prussiat of potash affords a green precipitate with small blue specks, which shows the presence of iron. In the fire, native antimony melts and is volatilized in white flowers; but a substance of a fat and oily appearance is formed round the fused metal in much greater abundance than with the pure metal. Mongez asserts, that this is the oxide converted into glass of antimony. On the first impression of the heat, a slight smell of arsenic is emitted, which quickly disappears. Mr. Sage, in fact, found sixteen per cent. of arsenic in the native antimony from Chalances, near Allemont, in Dauphiny. If this native ore be fused in a crucible without any reducing matter, a very neat button is obtained, susceptible of crystallization, more brilliant and clear in its fracture, which exhibits larger plates than before.

The appearances of this native metal, before the blowpipe, correspond with those observed in the larger process. It evaporates in smoke with a smell of garlic; a white powder is deposited on the charcoal, of which the arsenical portion becomes black and fixed, on application of the interior cone of the flame. The fluxes acquire a faint hyacinth tinge.

There is a native antimony at Andresberg, from 100 parts of which Klaproth obtained 98 antimony, 1 silver, and 0.25 iron. Its specific gravity was 6.72.

Mongez likewise acquaints us with a native oxide of antimony, observed by him, upon a piece of the native antimony from Chalances. It is usually crystallized in very white, slender needles, in some portions confused with the plates of the antimony, and in others, radiated from a centre exactly like the crystallized zeolite. These did not contain arsenic. The white earthy ore of Tornavara in Gallicia, is an oxide apparently produced from the decomposition of native sulphuret.

There is likewise a white antimonial ore, in which the oxide appears to be combined with muriatic acid; but it is very rare.

The most common and abundant ore of antimony is known in commerce simply by the name of antimony, and consists of the ore in combination with sulphur. It is composed of filaments, or needles, adherent to each other, either parallel, or divergent from a centre. These are friable, brilliant, usually of a shining metallic blueish-grey colour; sometimes of a lively chatoyant appearance, according to Mongez; but I think on recollection, not having a specimen of the sort before me, that these colours, though variegated, do not change their position with the eye of the observer, or at least exhibit none of that internal appearance denoted by the word chatoyant. They should, therefore, be called iridescent.

When this ore of antimony possesses a less determined internal structure, it may be mistaken for the small grained lead ore, or white silver ore, or iron glimmer; but it may be distinguished by the smell of sulphur it exhibits when broken or rubbed, and still more effectually by its fusibility, which is such that it runs in the flame of a candle. The sulphur may be easily separated, and its quantity ascertained by aqua regia, which dissolves the metal, and leaves the sulphur floating at the surface. The aqua regia, according to Kirwan, ought to consist of one part nitric and four muriatic acid.

The specific gravity of this ore of antimony is for the most part from from 4 to 4.2, and after fusion from 4.7 to 5. There are several varieties:

1. The gray striated ore of antimony.

2. Plumous ore of antimony. This has the form of small, silky, gray, or blueish filaments, almost always efflorescent. There are some specimens of a deep red, and of a pulverulent reddish colour, in prisms efflorescent upon the gray ore. The ore from Tuscany is of this kind. Mr. Sage considers the red plumous ore of antimony as a native golden sulphur, and the pulverulent reddish ore as a native kermes mineral.

3. The solid gray ore of antimony. This is an uniform mass, of the colour of polished iron or lead, very brittle, and its fracture exhibits small brilliant facets, and sometimes filaments. It melts and is volatilized by the flame of a candle.

The sulphuret of antimony urged by the flame of the blowpipe is liquefied, flows on the charcoal, soaks into it, and at length entirely disappears, except a portion of flowers, which are deposited circularly. One hundred parts of the ore contain twenty-four parts of antimony slightly oxided, and twenty-six of sulphur.

The red ore of antimony has the same texture with the common sulphureous ore, but its fibres are not so coarse. Wallerius distinguishes three varieties found in Hungary and Saxony, viz. the red, the violet, and the pale red.

Ores of Arsenic.

Arsenic is found native in Saxony, Bohemia, Hungary, and elsewhere, but par-

ticularly at St. Marie aux Mines in Alsatia It is often found of no determinate figure, friable, and pulverulent; but sometimes compact, divided into thick convex plates, with a needle-formed or micaceous surface. It is of a lead colour when fresh broken, and may be cut with a knife, like compact black lead, but soon blackens by exposure to the air. In hardness it seems to exceed copper, but is brittle like antimony. It burns with a small flame, and goes off in smoke. Cronstedt says nothing of the residue, but Bergman remarks, that he never found native arsenic without iron.

Native arsenic before the blowpipe, takes fire, emits a white smoke, and covers the charcoal, with flowers of arsenic, which quickly become black. A strong smell of garlic is emitted. If the portion of iron it contains, be considerable, it remains on the coal; if not, it disappears. It communicates a yellowish colour to the flux, which disappears in proportion as the arsenic is volatilized.

Native oxide of arsenic, is in general scarce. It is either in a loose or powdery form, or else in white semitransparent crystals. Like the artificial oxide, it is volatilized by heat, emitting a smell of garlic, and possesses the same solubility in water. See Arsenic. It does not detonate with nitre, though an effervescence arises. It is scarcely soluble in the sulphuric acid, something more in the muriatic, but most perfectly in the diluted nitric acid. Before the blowpipe, it evaporates in white flowers, which cover the charcoal. The peculiar smell of garlic, appears to be sufficiently distinctive of this semimetal; but Mongez observes, as the characteristic marks of the respective flowers of arsenic, antimony, and zinc, that the first, when distributed upon the charcoal, become suddenly black, if touched with the interior part of the flame, the second remain white, and the third become yellow.

The combinations of arsenic with sulphur, are either *orpiment* or *realgar*. These are also produced by art. See these words. Native orpiment is of a yellow colour, inclining to red in some specimens, and green in others. It is frequently mixed with yellow mica and spar, which cause it to appear as if compounded of facets, of greater or less magnitude. In the fire its colour becomes obscure, a white blueish flame appears, with a considerable mixed smell of garlic and sulphur. By an open fire it is almost entirely volatilized, and leaves only a greenish earthy residue; but in a close vessel it melts, and in cooling, becomes the reddish mass called realgar. It is easily distinguished from artificial orpiment, because its figure is almost always that of small, silky, light crystals, or granulated.

Native realgar has a more lively colour, and possesses every degree of transparency, from that of the clear red crystals, called the ruby of arsenic, which is compact and hard, to that of perfect opacity. Its habitudes before the blowpipe are the same as those of orpiment.

Bergman's method of analysing these ores, consists in digesting them in muriatic acid, adding the nitric by degrees, to help the solution. The sulphur will be found on the filter, and the arsenic will remain in the solution, from which it may be precipitated in its metallic form, by zinc, adding to the solution.

Mr. Chenevix gives the following, as the most certain mode of ascertaining the quantity of arsenic. Digest the ore, finely powdered, in nitric acid enough to acidify and take up all the arsenic. Pour off the liquor; boil the residuum in a little water, filter, and mix the two solutions. Neutralize the excess of acid by potash, taking care not to use it in excess, and nitrat of lead, as long as any precipitate takes place. Wash the precipitate in cold water, dry, and weigh it. As the arsenical ores, often contain sulphur, a little sulphat of lead, may be mixed with the arseniat; and to decide this, digest the powder in warm dilute muriatic or nitrous acid, and the arseniat will be dissolved, leaving the sulphat behind. One hundred parts of arseniat of lead, contain oxide of lead 63, water 4, arsenic acid 33, which are equivalent to 22 of the metal.

Arsenical ores, containing the other metals, are in general, distinguished by their respective denominations. The arsenical pyrites, or marcasite, contains sulphur and iron. It is of a gray ash colour, inclining to blue, either solid, or composed of small brilliant particles. It tarnishes in the air, gives fire with steel, and emits a smell of garlic. Sometimes it effervesces with the nitric acid, which partly dissolves it. In the fire it is volatilized, and forms a true realgar, which distinguishes it from mispickle, which contains iron and arsenic without sulphur, and might easily be confounded with it.

ORES of Bismuth. Bismuth is the most common of all native metallic substances. It is generally found either in cubes or octagons, or of a dendritical form, or else in thin laminæ investing the ores of other metals, particularly those of cobalt. As it is very fusible, it may easily be extracted by exposing the minerals, which contain it to a gentle heat. It then

exudes in small white globules, the more readily in proportion to its purity It effervesces with nitric acid, forming a solution at first milky, but which afterward becomes clear. It is said to be sometimes alloyed with silver, in which case a separation may easily be made, by adding water to the nitric solution, which throws down the bismuth, in the form of magistery.

Oxide of bismuth, is found of a whitish or greenish-yellow colour, frequently upon the other ores of bismuth, probably formed by decomposition. It is then called flowers of bismuth, and may be distinguished from the flowers of cobalt by the red colour of the latter; for the flowers of bismuth are never red, nor become so. This oxide is readily dissolved in nitrous acid, and may be precipitated by water.

The oxide of bismuth is reducible on charcoal, by the blowpipe, and melts in the spoon. With microcosmic salt, it affords a globule of a dull yellow colour, which becomes paler, and rather more opake by cooling. With borax, a mass is obtained in the spoon, which is gray upon the charcoal, and not easily cleared of small bubbles. This glass fumes when kept in a state of fusion, and forms a circle of a greenish-yellow colour around it, produced by the volatilization of part of the bismuth.

Bismuth is mineralized by sulphur. It resembles galena or potters' lead ore, in colour and appearance, is brittle, easily cut with a knife, and does not effervesce with acids, though soluble in aqua fortis. The solution is clear, and sometimes greenish. It is said to contain also cobalt and arsenic, but Mongez denies the latter. It is very fusible, and the sulphur mostly separates in scorification. There are two varieties; the one tessular like galena, from Bastnas in Sweden, and Schneeberg in Saxony, which is very scarce; the other striated, composed of scales or small needles, like the sulphureous ore of antimony, but does not soil the fingers. It comes from Schneeberg and Johann-Georgenstadt in Saxony.

Before the blowpipe this ore speedily melts, and affords a blue flame, with a smell of sulphur, but the perfect reduction is rather long and difficult. Bergman advises to precipitate the bismuth with a small quantity of cobalt, which penetrates the globule, by virtue of the sulphur. The mass then swells up, and produces a scoria, divided into very evident compartments. The scoria, kept a longer time in the fire, emits globules of bismuth.

Bismuth is also found mineralized with sulphur and iron. This ore is composed of small, thick, uniform scales, of a gray-yellowish colour, when recently broken, but more yellow where it has suffered exposure to the air. This species is more difficult to reduce, than the preceding, on account of the iron it contains.

Wallerius, Sage, and Rome de Lisle, mention an ore of bismuth, mineralized with sulphur and arsenic, which is of a shining appearance, of a whitish-yellow, or ash colour, composed of scales, in general small, hard, sometimes giving fire with a steel, not effervescent with nitric acid, though partly soluble. Mongez is disposed to think it merely the sulphureous ore of bismuth, already mentioned, but observes, that the presence of arsenic cannot but show itself, by its peculiar smell when heated. See Bismuth.

ORES of Cerum are not much known.

ORES of Chrome. See Chrome.

ORES of Cobalt. Cobalt has not been found in a state of native purity, but the combination of this semimetal with arsenic and iron in the metallic form usually passes for such. The quantity of iron is small. This ore is solid, hard, ponderous, of a gray colour, more or less obscure, sometimes inclining to red. Its fracture is granulated, not unlike some kinds of steel. It commonly gives fire with the steel, and emits a strong smell of garlic. In the fire it becomes black. Nitric acid dissolves it with effervescence, which affords a sympathetic ink, by the addition of muriatic acid.

There are two characters which readily distinguish this mineral from the white, and gray ores of arsenic.

1. It forms a sympathetic ink, with aqua regia; and

2. It affords a blue glass with borax, whereas that of the ore of arsenic is black. There are two varieties, the one solid and compact, the other granulated and easily broken, beside that its colour is of a reddish-white, and sometimes a little hepati.

Before the blowpipe, this ore first emits a strong smell of garlic, then becomes black and melts into a small globule of the metal. It give a blue colour to the fluxes.

The oxide of cobalt, is commonly found in the earth mixed with arsenic, iron, or copper; but whether mechanically, or more intimately combined, is doubted by Bergman. It is usually of a gray-black; but sometimes so black, that it might be taken for soot. It soils the fingers, and is almost always friable and pulverulent. On breaking a compact specimen, rose-coloured spots may frequently be observ-

ed, resembling the flowers of cobalt. It is seldom without a mixture of a small portion of oxide of iron. When solid, it sometimes has the resemblance and form, of a vitreous scoria, whence some mineralogists have called it the vitreous ore of cobalt, or slag. These are free from sulphur and arsenic. Cronstedt compares the friable ore, or cobalt ore, to the artificial zaffre. Mongez says, it contains clay.

Before the blowpipe, as the black oxide of cobalt is always mixed with a small portion of the red oxide, which is arsenical, it emits a slight smell of garlic. The reduction is very difficult But it dissolves in borax, gives it a blue colour, and is partly reduced in a small metallic globule, which occupies the lower part of the flux.

The arseniat of cobalt, cobalt bloom, or red cobalt ore, generally occurs mixed with other cobalt ores, or as a covering to them. It is sometimes found in crystallized quadrangular prisms, terminated by dihedral pyramids.

Baron Born, mentions a sulphuret of cobalt, in external characters, very like the white cobalt ore, but perfectly free from arsenic and iron. There is likewise a sulphat of cobalt, in transparent stalactitical crystals, of a pale red colour.

ORES of Columbium, are not much known.

ORES of Copper. Copper is not, according to the opinion of Bergman, found native without a mixture of gold, silver, or iron. Some specimens, however, nearly resemble the refined copper in colour, malleability, and ductility. Others, instead of possessing the reddish colour, are rather of a yellow or brown colour, with green or blue spots of rust.

It is found in two different forms: 1. Solid native copper, which is either crystallized or in grains, or thin leaves, threads or dendrites, adherent to different matrices, such as calcareous stones, spars, quartz, petro-silex, jasper, schistus. There are few copper ores, according to Mongez, which do not contain some of these varieties.

2 Native copper in the form of small or imperfectly coherent grains. This copper appears to have been deposited from mineral waters, by means of iron, for which reason it is called cement copper.

Kirwan directs the humid assay of native copper, by nitric acid. The gold, if it contain any, remains undissolved in the form of a black powder, which may be taken up and examined by aqua regia. The silver may be precipitated from the nitric solution, by muriatic acid, or better by copper; and the iron falls down in the form of an insoluble oxide, by sufficient ebullition with water.

The oxided copper ores, are either of a red, blue, or green colour.

The red copper ore, is rather scarce. In some specimens, it is of a beautiful red, or of a brown-reddish liver colour, whence it has obtained the name of hepatic ore. When in a loose form, it is called copper ore; but generally it is moderately hard, though brittle, sometimes crystallized and transparent, either in a capillary form, or in cubes, prisms, or pyramids. Mongez says, that the most common form, is that of fine grains, resembling the flowers of cinnabar. It is easily distinguished by its brightness, and ruddy colour, which approaches that of copper. It effervesces with acids, which dissolve it, as well as the other oxides of copper. Another common character of these ores is, that they blacken in a moderate heat, to which may be added, the property of affording a blue colour with ammonia.

According to Fontana, quoted by Kirwan, a hundred parts of this ore contain seventy-three of copper, twenty-six of carbonic acid, and one of water. Bergman also found it to contain carbonic acid. According to Mr. Chenevix, however, the red octaedral copper ore consists of a pure oxide, containing 88.5 per cent. of metal; and is therefore highly valuable, not merely for its richness, but for the purity of the metal, which is easily obtained from it. The brown or hepatic ore contains a variable proportion of iron or pyrites, and sometimes sulphuret of copper, and hence affords from 20 to 50 per cent. of copper. It is often iri-descent.

The blue copper ore, most frequently appears in a loose form, though sometimes indurated and even crystallized, but it is then mixed with quartz. It frequently lines the internal cavities of different matrices. When the blue colour is very lively, it is called azure of copper, when paler, mountain blue, and when abounding with earthy matter, blue chrysocolla. It must be confessed, however, that these terms are by no means accurately applied, but taken for the most part indiscriminately. Morveau, in the Memoirs of Dijon, has inferred from experiment, that the oxides of copper are determined to a blue rather than to a green, by a nearer approach to the metallic state; but on this head, see Verditer.

The green copper ore, is distinguished by the names mountain green, or green chrysocolla." It is found in two states, either earthy and friable, of a more or less

deep green, or else solid and crystallized. The most beautiful specimen is the silky copper ore, so called, because its texture exhibits long shining filaments.

The solid green ore is usually called malachite.

Analogous to the oxided copper ores, is the lapis armenus, a blue stone, that does not admit of a polish, and consisting of calcareous earth of gypsum, penetrated with the blue oxide of copper; hence it sometimes effervesces with acids, and sometimes not; but never gives fire with steel. It loses its colour when well heated in the fire. This stone is very different from the lapis lazuli, since this last contains no copper.

Bergman from Werner mentions a copper ore, consisting of that metal mineralized by carbonic acid, and combined with clay. This is most commonly superficial, in small crystals of a beautiful green, or in small scales, and was formerly considered as a variety of mica or talc. Nitric acid dissolves it very well, and the solution takes a green colour. The copper may be precipitated in the usual manner. The blowpipe does not fuse this ore, if the flame be directed against its flat surface; but if the edge be attacked, it speedily melts into a black scoria. With borax it affords a brown yellow glass, and with microcosmic salt a glass of a fine grass green.

Copper mineralized by sulphur, is commonly denominated the vitreous copper ore. Its colour is red, brown, blue, violet, or gray; it is generally so soft as to be cut with a knife, and shows a polished gold-coloured surface where cut. As to form, it is sometimes crystallized in regular figures, and sometimes irregular. In its fracture it often shows violet, reddish, and variable colours. It is much more fusible than pure copper, and may be melted by a candle. Its specific gravity is from 4.129 to 5.338. It is found in the mines of other copper ores, and in the lime-stone, spar, quartz, mica, and clay; it is the richest of all the copper ores, and the gray affords sometimes, from 80 to 90 per cent. of copper, 10 or 12 of sulphur, with a small proportion of iron: the red ores are the poorest, containing most iron.

This ore may be reduced with considerable facility, by the blowpipe, but it is not easy to scorify and separate the last portions of iron and sulphur. To analyse the ore, Bergman advises a solution of it in five times its weight, of concentrated sulphuric acid by ebullition, to dryness, and the subsequent addition of as much water, as will dissolve the sulphat thus formed. This solution he precipitates, by a clean bar of iron, and thus obtains the copper in its metallic form. If the solution be contaminated with iron, he redissolves the impure copper thus obtained, in the same manner, and so procures a rich solution; which he again precipitates with iron.

The variegated copper ore, differs from the vitreous ore, only in containing more iron, of which the proportion is from 20 to 50 per cent. Its colour consists of various shades of blue, or reddish blue. It is as hard or harder, than the preceding, and its fracture is reddish, and polished like glass. It is more difficultly reduced by the blowpipe, and may be analysed in the humid way, by the same treatment.

The yellow copper ore, or copper pyrites, contain a large proportion of iron, mineralized with sulphur. It is sometimes found crystallized, and sometimes irregularly formed. The crystallized sort contains the smallest portion of copper, which is sometimes so trifling, that the ore may be considered as a martial pyrites, though an experienced eye, may discern a difference between them. The copper scarcely exceeds 40 per cent. in any of the specimens.

When this metal is sufficiently abundant, to be wrought with profit, it may be roasted, and the sulphur preserved toward defraying the expenses. The residue being exposed to the united action of air and water, in a proper situation, will afford the sulphat of copper, which may either be crystallized for sale, or precipitated by fragments of old iron, as is advantageously done at the Paris-mountain mine, in the isle of Anglesea, and elsewhere. When rich in copper, it is a brilliant yellow colour, sometimes approaching to red; in other samples it is greenish, from the admixture of these two colours. The colours are more neat and lively, at the place of fracture, than after exposure to the air, which changes them. It is not very hard, is considerably brittle, and scarcely gives fire with the steel. Its friability is greater, the larger the proportion of sulphur, and the less of iron. It affords several varieties.

1. Yellow copper ore, which is solid, ponderous, brilliant, and close in its fracture.

2. The yellow ore, which, though hard, has a laminated fracture; this is the most common of any.

3. Green yellowish copper ore; it contains the largest portion of sulphur, and the least of iron.

4. Crystallized yellow copper ore; it is the copper pyrites, properly so called, containing the least proportion of copper,

and the most of iron. When this is met with among rich ores, it is thrown aside, because of its difficult reduction and small produce, which does not exceed four or five pounds of copper, in the hundred weight of ore. Its colour varies, being sometimes reddish, or resembling a pigeon's neck; when yellow, it is paler than the first variety here mentioned. The management of this ore in the analysis, may be gathered from what has already been said. It may be readily fused by the blowpipe into a black matt, but it requires a continuance of the heat for a long time, before the globule of copper becomes disengaged.

The gray copper ore, appears to owe its character to antimony, which exists in it together with iron and sulphur. It sometimes contains silver, and a large proportion of lead. The copper amounts to between sixteen and thirty-two parts in the hundred.

The colour of this ore is an obscure or blackish gray: it is hard, and the antimony it contains, renders it brittle.

The count de Bournon and Mr. Chenevix, have lately described and analysed with great minuteness, various arseniats of copper.

1. Crystallized in obtuse octaedra; of a beautiful deep sky blue, sometimes inclining to Prussian blue, frequently a fine grass or apple green, and sometimes nearly white, with a blue cast. Specific gravity 2.881.

2. In hexaedral laminæ; generally of a fine deep emerald green, but sometimes lighter. Specific gravity 2.548

3. In acute octaedra; of a brown or bottle green. Specific gravity 4.210. Of this there are several varieties, in one of which, the amianthiform, the colour varies through different shades of a green to a golden brown, straw colour, and even satiny white.

4. In trihedral prisms; of a blueish green, or deep verdigrise colour, but easily decomposed, and then turning black on the outside. Specific gravity 4.28

The third species above mentioned gave Mr Chenevix 60 per cent. oxide of copper, 39.7 arsenic acid. The rest appeared to be arseniated hydrats of copper, containing from 14 to 29 per cent. arsenic acid, and from 16 to 35 water.

There is a bituminous copper ore, or pitcoal, containing copper, which is found in Sweden, Hungary, and Alsatia. It takes fire without much difficulty, burns slowly, and leaves ashes, from which copper is extracted. This is probably the same substance mentioned by Brunnich on Cronstedt, p. 698, which is called pitch ore, in the Bannat of Temeswar. Gellert, in his Metallurgic Chemistry, mentions a copper ore of the colour of pitch, which resembles a vitrified scoria, and Raspe informs us, that copper has been found in Cornwall, mixed with black pitchy rock oil.

Copper is also obtained from waters in which it is combined with the sulphuric and sometimes with the muriatic acid, no doubt produced by the decomposition of some of the ores above mentioned. Animal and vegetable substances are sometimes found penetrated with copper.

We shall conclude this article by inserting some processes for the reduction of copper ores in the furnaces, taken from Cramer.

Process I.

To reduce and precipitate copper from a pure and fusible ore in a close vessel.

Mix one, or, if you have small weights, two docimastical centners of ore, beaten extremely fine, with six centners of the black flux; and having put them into a crucible or pot, cover them one inch high with common salt, and press them down with your finger: but let the capacity of the vessel be such, that it may be only half full; shut the vessel close, put it into the furnace, heap coals upon it so that it may be covered over with them a few inches high; govern the fire in such a manner, that it may at first grow slightly red-hot; soon after you will hear the common salt crackle, which will be followed by a gentle hissing noise. As long as this lasts, keep the same degree of fire till it ceases. Then suddenly increase the fire, either with the funnel and cover put upon the furnace, or with a pair of bellows applied to the hole of the bottom part, that the vessel may become strongly ignited. Thus you will reduce and precipitate your copper in about a quarter of an hour: then take out the vessel, and strike with a few blows the pavement upon which you put it, that all the small grains of copper may be collected into one mass.

Break the vessel, when grown cold, in two, from top to bottom, as nearly as you can: if the whole process has been well performed, you will find a solid, perfectly yellow, and malleable button adhering to the bottom of the vessel, with scoriæ remaining at top of a brown colour, solid, hard, and shining, from which the button must be separated by several gentle blows of a hammer: when this is done, weigh it, after having wiped off all the impurities.

A soft, dusty, and very black scoria is a sign the fire was not sufficiently strong.

Small neat grains of copper reduced, but not precipitated, and adhering still to scoriæ, especially not very far from the bottom, and an unequal and ramified button, are signs of the same thing. A solid, hard, shining, red-coloured scoria, especially about the button, or even the button itself, when coloured with a like small crust, are signs of an excess in the degree and duration of the fire.

Remarks. All the ores which are easily melted in the fire, are not the objects of this process; for they must also be very pure. Such are the vitreous copper ores; but especially the green and azure-coloured ores, and the cæruleum and viride montanum, which are not very different from them. But if there be a great quantity of arsenic, sulphur, or of the ore of another metal and semimetal, joined to the ore of copper, then you will never obtain a malleable button of pure copper, though ores are not always rendered refractory by the presence of these.

Process II.

To reduce and precipitate copper out of ores rendered refractory by earth and stones that cannot be washed off.

Beat your ore into a very subtile powder, of which weigh one or two centners, and mix as much sandiver with them. This done, add four times as much of the black flux with respect to the ore; for by this means the infusible terrestrial parts are better disposed to scorification, and the reducing flux may act more freely upon the metallic particles, set at liberty.

As for the rest, proceed as in the last process: but you must take the fire a little stronger for about half an hour together. When the vessel is grown cold and broken, examine the scoriæ, whether they be in the state they ought to be. The button will be as fine and ductile as the foregoing.

Remark. As these copper ores contain scarcely any sulphur or arsenic, the roasting would be of no effect, and much copper would be lost. For no metallic oxide, except those of gold and silver, improperly so called, can be roasted without some loss of the metal.

Process III.

To precipitate copper out of an ore that contains iron.

Act in every respect according to the last process. But you will find, after the vessel is broken, a button by no means so fine, but less ductile, wherein the genuine colour of the copper does not perfectly appear, and which must be farther purified.

Remarks. The fire used in this operation is not so strong as to reduce and fuse iron alone. But copper dissolves iron in the dry way, though of itself very refractory in the fire. And for this reason, while the ore and the flux are most intimately mixed and confounded by trituration, the greater part of the iron will combine with the copper in its metallic state.

Process IV.

The roasting of pyritose, sulphureous, arsenical, semimetallic copper ore.

Break two docimastical centners of the ore to a coarse powder, put them into a test covered with a tile, and place them under the muffle of a docimastical furnace. The fire must be so gentle, that the muffle may be but faintly red-hot: when the ore has decrepitated, open the test, and continue the fire for a few minutes; then increase it by degrees, that you may see the ore perpetually smoking a little: in the mean time, it is also proper now and then to stir it up with an iron hook. The shining particles will assume a dark red or blackish colour. This done, take out the test, and let it grow cold. If the small grains be neither melted, nor strongly adherent to each other, the process has been well conducted: but if they run again into one single cake, it must be repeated with another portion of the ore, in a more gentle fire.

When the ore is grown cold, beat it to a powder somewhat finer, and roast it by the same method as before; then take it out, and if the powder be not yet melted, beat it again to a very subtile powder; in this you are to take care that nothing is lost.

Roast the powder in a fire somewhat stronger, but for a few minutes only. If you do not then find the ore in any respect inclined to melt, add a little tallow, and burn it away under the muffle, and repeat the operation, till, the fire being very bright, you no longer perceive any sulphureous, arsenical, unpleasant smell, or any smoke; and there remains nothing but a fine soft powder of a dark red, or blackish colour.

Remarks. Every pyrites contains iron with an unmetallic earth, with sulphur, or arsenic, and most commonly both. Besides, as the copper in pyrites is exceedingly variable in quantity, their disposition in the fire must vary accordingly. For instance, the more copper there is in pyrites, the more it inclines to colliquation. The more sulphur and arsenic it contains,

the more fusible it will be; and the more iron and unmetallic earth it contains, the more refractory it will prove in the fire.

If such pyrites melt in the roasting, as is the case with some of them, or if they grow but red-hot, the sulphur and arsenic become so strictly united to the fixed part, that it is almost impossible to dissipate them. For in this case, when the matter is again reduced into a powder, a much greater time and accuracy are required in the management of the fire to perform the operation. For this reason, it is much better to repeat it with new pyrites. But you must roast no more than twice the quantity at once of the ore you are inclined to employ in the foregoing experiment; in order that, if the precipitation by fusion should not succeed, there may still remain another portion for use, instead of your being obliged to repeat a tedious roasting.

If you observe the signs of a ferruginous refractory pyrites, the operation must be performed with a stronger fire, and with much greater speed. However, you must be careful not to perform it with too violent a fire: for a large proportion of copper is destroyed not only by the arsenic but by the sulphur; and this happens even in vessels nearly closed, when the sulphur is expelled by a fire not quite so strong. By repeated and gentle sublimation of the sulphur in a vessel, both very clean and well closed, this fact will be clearly seen.

When the greater part of the sulphur and the arsenic is dissipated, you may make a stronger fire; but then it is proper to add a little fat. Cramer here accounts for the advantage produced by the fat, by observing, that it dissolves mineral sulphur. In fact, it reduces and volatilizes the last portions of arsenic, and at the same time, as he justly remarks, prevents that extreme scorification of the copper, which would greatly impede its subsequent reduction. Hence he adds, the reason is plain, why assayers produce less metal in the trying of veins of copper, lead, and tin, than skilful smelters do in large operations. For the former perform the roasting under a muffle, with a clear fire, and without any oily reducing matter; whereas the latter perform it in the middle of charcoal or of wood, which constantly tend to reduce the oxides.

The darker and blacker the powder of the roasted ore appears, the more copper you may expect from it. But the redder it looks, the less copper and the more iron it affords; for roasted copper dissolved by sulphur, or the acid of it, is very black; and iron, on the contrary, very red.

Process V.

The precipitation of copper out of roasted ore of the last process.

Divide the roasted ore into two parts, and reckon each of them a centner: add to it the same weight of sandiver, and four times as much of the black flux, and mix them well together. Manage the rest of the operation in every respect according to process I. The precipitated button will be slightly malleable, sometimes brittle, now and then very much like pure copper in its colour, but sometimes whitish, and even blackish. Whence it is most commonly called black copper, though it is not always of so dark a colour.

It is easy to conceive, that there is as great a difference between the several kinds of the metal called black copper, as there is between the pyritose and other copper ores accidentally mixed with other metallic and semimetallic bodies. For all the metals, the ores of which are intermixed with the copper ores, being reduced, are precipitated together with the copper; which is brought about by means of the black flux. Hence, iron, lead, tin, antimony, bismuth, are most commonly mixed with black copper in a variety of different proportions.

Indeed, it is self evident, that gold and silver, which are dissolvable by all these matters, are collected in such a button, when they have previously existed in the ore. And moreover, sulphur and arsenic are not always entirely absent. For they can hardly be expelled so perfectly, by the many preceding roastings, but there will remain some vestiges of them, which are not dissipated by a sudden melting, especially in a close vessel, wherein the flux swimming at top hinders the action of the air. Indeed, arsenic is rather fixed by the black flux, and assumes a semimetallic form, while it is at the same time preserved from dissipating by the copper.

Process VI.

To reduce black copper into pure copper by scorification.

Separate a specimen of your black copper, of the weight of two docimastical centners at least; and perform this in the same manner, and with the same precautions, as if you would detect a quantity of silver in black copper.

Then with lute and coal-dust make a bed in the cavity of a moistened test:

when this bed is dry, put it under the muffle of a docimastical furnace, in the open orifice of which there must be bright burning coals, with which the test must likewise be on all parts surrounded. When the whole is perfectly red-hot, put your copper into the fire alone, if it contain lead; but if it be entirely deprived of it, add a small quantity of glass of lead, and with a pair of hand-bellows increase the fire, that the whole may speedily melt: this done, let the fire be made a little less violent, and such as will be sufficient to keep the metallic mass well melted, and not much greater. The melted mass will boil, and scoriæ will be produced, that will gather at the circumference. All the heterogeneous matters being at last partly dissipated, and partly turned to scoriæ, the surface of the pure melted copper will appear.

As soon as you perceive this, take the pot out of the fire, and extinguish it in water: then examine it in a balance; and if lead has been at first mixed with your black copper, add to the button remaining of the pure copper, one fifteenth part of its weight which the copper has lost by means of the lead; then break it with a vice; and thus you will be able to judge by its colour and malleability, and by the surface of it, after it is broken, whether the purifying of it has been well performed or not. But whatever caution you may use in the performing of this process, the product will notwithstanding be always less in proportion than what you can obtain by a larger operation, provided the copper be well purified in the small trial.

Remarks. This is the last purifying of copper, whereby the separation of the heterogeneous bodies, begun in the foregoing process, is completed as perfectly as it possibly can be. For, except gold and silver, all the other metals and semimetals are partly dissipated and partly burnt, together with the sulphur and arsenic. For in the fusion they either turn of themselves to scoria and fumes, or this is performed by means of iron, which chiefly absorbs semimetals, sulphur and arsenic, and at the same time they accelerate its destruction. Thus the copper is precipitated out of them pure: for it is self-evident, that the unmetallic earth is expelled, the copper being reduced from a vitrescent earthy to a metallic state; and the arsenic being dissipated, by means of which the said earth has been joined to the coarser buttons of the first fusion. But there is at the same time a considerable quantity of the copper that mixes with the scoriæ, though a great part of it may be reduced out of them by repeating the fusion.

The fire in this process must be applied with all possible speed, to make it soon run: for, if you neglect this, much of your copper is burnt; because copper that is only red-hot cleaves much sooner, and in much greater quantity, into half-scorified scales, than it is diminished in the same time when melted. However, too impetuous a fire, and one much greater than is necessary for its fusion, destroys a much greater quantity of it than a fire only sufficient to fuse it. For this reason, when the purifying is finished, the melted body must be extinguished in water together with the vessel, lest, being already grown hard, it should still remain hot for a while; which must be done very carefully to prevent dangerous explosions.

The scoria of the above process frequently contains copper. To extract which, let two or three docimastical centners of the scoria, if it be charged with sulphur, be beaten into a subtile powder, and mix it, either alone, or, if its refractory nature require it, with some very fusible, common, pounded glass, without a reducing saline flux, and melt it in a close vessel, and in a fire having a draught of air; by which you will obtain a button.

But when the scoria has little or no sulphur at all in it, take one centner of it, and with the black flux manage it as you do the fusible copper ore (process I.); by which you will have pure metal.

Process VII.

To assay Copper ores.

Roast a quintal of ore (after the manner described in process IV); add to it an equal quantity of borax, half a quintal of fusible glass, and a quarter of a quintal of pitch: put the mixture in a crucible, the inner surface of which has been previously rubbed with a fluid paste of charcoal-dust and water; cover the whole with pounded glass mixed with a little borax, or with decrepitated sea-salt; put a lid on the crucible, which you will place in an air furnace, or in a blast furnace: when the fire shall have extended to the bottom of the coals, let it be excited briskly during half an hour, that the crucible may be of a brisk red colour; then withdraw the crucible, and when it is cold break it; observe if the scoria be well made: separate the button, which ought to be semiductile, and weigh it. This button is black copper, which must be purified as in process VI.

If the ore be very poor, and enveloped

in much earthy and stony matters, to a quintal of it, a quintal and a half of borax, a quarter of a quintal of pitch, and ten pounds of oxide of lead or minium, must be added. The oxide of lead will be revived, and will unite with the scattered particles of the copper, and together with these will fall to the bottom of the crucible, forming an alloy. When the ores of copper are very rich, half a quintal of borax, and a quarter of a quintal of glass will be sufficient for the reduction. If the ore be charged with much antimony, a half or three quarters of a quintal of iron filings may be added; otherwise the large quantity of antimony might destroy the copper, especially if the ore contained no lead. If iron be contained in copper ore, as in pyrites, some pounds of antimony, or of its sulphuret, may be added in the assay; as these substances more readily unite with iron than with copper, and therefore disengage the latter metal from the former.

Ores of Gold.

From the unchangeableness of gold by the solvents usually disengaged in nature, it is comparatively very seldom found but in the native state. In this state it is never absolutely pure, but always mixed either with silver, copper, or iron. It is usually found in rocks of quartz, always in small particles or masses. The sands of several rivers afford it in small plates or leaves. Most great rivers carry gold with them, even such as do not take their rise in mountains where gold is found. In the south of France, in Transylvania, and elsewhere in Europe, this gold is separated by washing off the sand; but the produce is not sufficient in general to pay any rent, or employ capital. It merely affords subsistence to such poor families as apply to this species of industry, particularly after the torrents occasioned by heavy rains. If a hundred pounds of sand contain twenty four grains of gold, it is said the separation is worth attending to; but in Africa, five pounds of sand often contain sixty-three grains of gold. The heaviest sand, which is often black or red, yields most.

Daubenton distinguishes eight varieties of native gold.

1. In powder.
2. In grains.
3. In small spangles.
4. In masses.
5. In filaments.
6. In branches like vegetables.
7. In small plates; and
8. In octaedral crystals.

Gold is found mineralized by sulphur together with iron, which is supposed to be the connecting medium. This is the auriferous pyrites. It is close and compact, of a brighter and more lively yellow than the ordinary pyrites; notwithstanding which, they are, as Mongez says, very difficult to be distinguished. The gold cannot be extracted by aqua regia, or by amalgamation, but the last-mentioned author gives the following simple method for this purpose: Take a small quantity of this pyrites, and digest it in the nitric acid. All the foreign matters will be dissolved, except the g ld and sulphur, which will fall to the bottom. Wash the residue under water till nothing more remains but a yellow brilliant powder. This is the gold. According to Mr. Sage, one half as much more gold is extracted from the pyrites by this method than by treatment with lead.

This pyrites, according to Cronstedt, sometimes contains an ounce of gold in the hundred pounds. Some samples contain a portion of zinc as well as iron, and even copper, which gives the mass a greenish tinge. It is found at Adelfors in Sweden, in Hungary, Mexico, the island of Sumatra, Switzerland, and Dauphiny in France. Cronstedt remarks, that no pyrites ought to be despised which are found in tracts where gold ores are obtained. Brunnich on Cronstedt affirms, that the Transylvanian gold pyrites, in which no gold can be discovered by the eye, contained from fifty to one hundred and ten ounces, and upwards, in the hundred weight; and that those where the gold appears in the pyrites like mixed Spanish snuff, contained two hundred and fifty ounces, but they are very scarce.

Gold is found in Hungary united with mercury and sulphur. It is the auriferous cinnabar.

There is likewise a blend or ore of zinc found at Chemnitz in Hungary, which contains silver and gold. It is usually of a red or black colour.

The auriferous ore of Nagayac in Transylvania is mentioned by Bergman as a compound of gold, silver, lead, and iron, mineralized by sulphur. The ore is of a gray colour, more or less obscure, in irregular masses; but sometimes, also, it is composed of slender, flexible leaves of no great consistency; it may be cut with a knife, is soluble in acids with effervescence, and the solution appears clear and colourless. Its specific gravity is 8.919.

By Ruprecht's analysis 100 parts gave, sulphur 41.66, oxide of lead 25, oxide of iron 16 66, gold 11.66, silver 2 33, oxide of arsenic 1, oxide of antimony 2.08. Some specimens, however, are said to contain 25 per cent. of gold combined with silver.

Klaproth, however, found in it but little sulphur, and a new metal. The foliated sort afforded him in 100 parts, lead 50, tellurium 33, gold 8.5, sulphur 7.5, silver and copper 1. The yellow gold ore of Nagyac gave, tellurium 45, gold 27, lead 19.5, silver 8.5, sulphur an atom. From the white gold ore, or aurum graphicum, of Offenbanya, in Transylvania, he obtained tellurium 60, gold 30, silver 10: and from that called aurum problematicum, or paradoxum, tellurium 92.55, iron 7.2, gold 0.25.

For other remarks on the treatment of gold, and its ores, see the article GOLD. The new process of amalgamation, invented by Baron Born, has very much engaged the attention of mineralogists; for which reason, as well as for its own intrinsic value, we shall here give an account of the process, from Raspe's translation of the baron's work on this subject.

The amalgamation of gold and silver ores, in large operations, as well as in smaller assays, requires the following distinct operations:

Stamping, grinding, and sifting.

Calcination, and repeated grinding and sifting.

Trituration.

Washing of the residuum.

Eliquation of the amalgama.

Heating of the same.

Distillation of the quicksilver pressed from the amalgama.

Refining of the heated quicksilver; and lastly,

Management, use, and refining of such residua as still appear to contain some of the nobler metals.

Stamping, grinding, and sifting.

By these operations the picked ores, black copper, and mixtures of metals and semi-metals are reduced into fine powder; and their surfaces being thus increased, they mix and calcine better with the common or rock salt, which is added to them; otherwise, the calcining fire and the air could not act sufficiently on the grosser particles, nor could the sulphuric and muriatic acids properly penetrate them, or a perfect desulphuration and decomposition of such substances be brought on, in which the gold and silver particles are disguised.

These operations are performed at Glasshutte, near Schemnitz in Hungary, in dry stamps and mills; but at Joachimsthal in Bohemia, wet stamps have been substituted, by which means the loss of dust unavoidable in the dry grinding, and also the injury otherwise done to the health of the workmen, are prevented.

Calcination.

Sulphur can be expelled from ores in open fire and in closed vessels but imperfectly, unless some proper substance be added. Thus, for example, corrosive sublimate is used in order to separate the sulphur from some ores; in this case the concentrated muriatic acid unites with the metallic, semi-metallic, and soluble earthy particles, passes into the receiver with the arsenic and oxide of antimony, and the disengaged quicksilver sublimes with the disengaged sulphur in the form of cinnabar.

From this an idea may be formed of the calcination of those ores, which, beside particles of native metal, contain disguised gold and silver, which would never be got entirely by washing or other mechanical contrivances, without some chemical assistance. This is their calcination. By fire and air it decomposes the ores, expels the sulphur, puts the metallic and semi-metallic particles into the state of oxide, and, freeing the noble metals from their disguises, exhibits them naked in their metallic form.

If there be sulphur enough, or even a superabundance of it, calcination will produce this desirable effect without any other addition But as the sulphuric acid acts on the ores, and disengages the gold and silver particles only in proportion as it is produced from the sulphur in more or less quantity, it is safer to depend on the muriatic rather than the sulphuric acid: and though common or rock salt, added in the process of amalgamation of well calcined ores, answers this end in some respects, yet it will serve better when mixed in proper proportions with the earthy or metallic ores before they go to the calcining fire, thus undergoing with them a similar calcination. The quantity in which it is to be added must be determined by experience.

When picked and halvan ores are calcined with common salt, the sulphur and arsenic, if any, begin first to be disengaged. Part of the sulphur flies off undecomposed, a great part is converted into sulphuric acid, which last, uniting with the alkaline and metallic earths of the base metals and semi-metals, but in particular with the mineral alkali of the common salt, forms with the first, different earthy and metallic (more or less soluble) neutral salts, and with the last, sulphat of soda. The muriatic acid thus disengaged begins now to act like the sulphuric, and is absorbed equally by the earths and the metallic oxides.

The muriatic acid consequently penetrates the alkaline and metallic earths

more completely than the sulphuric alone; for if there be salt enough, it decomposes all the sulphuric, earthy, and metallic neutral salts, by its different elective attractions, forming therewith various new deliquescent and very soluble earthy and metallic neutral salts, by which all the disguised gold and silver particles are disengaged, laid bare, and fitted for amalgamation.

When auriferous or argentine mixtures of base metals and semi-metals undergo calcination, fire and air will produce it in part, but slowly and imperfectly; whereas with common salt, or properly its acid, it succeeds quicker and better. There is no sulphur here, or its acid, to decompose the salt and disengage its acid; but common salt decomposing by continued heat, its acid separates from its alkaline basis, and acts immediately as a solvent of the metallic and semi-metallic particles. The elective attraction of these metals and semi-metals seems even to assist the decomposition and power of the salt.

The different mixtures of these alloys account for the different muriatic, metallic, and semi-metallic neutral salts. For instance, the alloys produced by the fusion of the Hungarian fallow, or gray copper ores, consist of antimony, copper, gold and silver, and sometimes also of some arsenic and iron, which in the alloys from common antimonial gray copper ores is but in a very inconsiderable proportion. The muriatic acid, disengaged from the salt, unites (gold and silver excepted) with the other metals and semi-metals, which by calcination leave the gold and silver bare and undisguised.

The same thing happens in the calcination of auriferous or only argentine black coppers. By the addition of common salt, the copper, iron, arsenic, and sometimes the antimonial particles are not only oxided, but also most of the antimony and arsenic is volatilized and destroyed.

The cobalt alloys produced in the treatment of arsenical cobalt and silver ores contain very often a great quantity of bismuth. The calcination with common salt acts upon them in a similar manner; but should they abound in bismuth, which is exceedingly fusible, this semimetal must be taken out by eliquation, before they can be well calcined, otherwise the bismuth would run, and, if not wholly prevent, yet very much hinder the oxidation of the other metallic and semimetallic particles.

In calcining mixtures which abound in antimony, and particularly in arsenic, it has been frequently found, that more or less quantities of silver and copper are carried off by the antimonial and arsenical muriat, chiefly when the calcining heat has been too sudden and brisk for the purpose of a quick oxidation of the antimony, and expeditious expulsion of the arsenic; for these volatile semimetals acquire, by the muriatic acid, a much greater than their natural power to carry off and volatilize even the finest metals.

Whatever these mixtures are, or may be, they must have gone through the stamps and mills, and have been completely pulverized, before they can be committed to the calcining fire, which is a flaming fire kept up by the worst of fuel; or to the calcining furnace, which consists of two hearths, which, taken together, are 11 or 12 feet by 5, of a grate, smoke and dust chambers, communicating with a flue, and sliding dust-stoppers, or dust-dampers.

The proportion and mixture of the picked and halvan or stamp-stuff is (in Hungary) determined by and depends upon the respective produce of the mines and stamps, which is commonly two in three; and with regard to the silver, upon their average produce. The proportion of the salt is regulated and determined by the more or less quantity of the sulphur of the said picked and halvan ores.

Thus, for example, a whole work, parcel, or stem of a calcining furnace in the quick-mills in Lower Hungary, consists of 30 cwt.; one third or 10 cwt. of which are pulverised picked ore; and two thirds, or 20 cwt. pulverised stamp or halvan ore. Sometimes it consists of two fifths of the former and three fifths of the latter; and in that proportion it contains, upon an average, three and a half, three and three quarters, or four ounces of silver per cwt. To such a mixture they generally add eight per cent. of rock salt.

The calcination of mixtures of base metals and semimetals, of silvery black coppers, and of leadish ores, requires, over and above the salt, an addition of quicklime, from four to ten or twelve per cent. For these metallic mixtures otherwise rise amazingly in the calcining heat, and the speiss and black coppers are in particular apt to turn clammy, and to leave clots, in which many particles remain uncalcined; but both these inconveniences are counteracted by the lime. It prevents the immediate contact of the metallic particles, and their running in the calcining fire: moreover, as it increases the surface of the whole mixture, the single parts of the same are more effectually acted upon, oxided, and laid bare by the fire, air, and muriatic acid.

When the furnace is properly heated, and the doors of the dust-chambers, and

the sliding-dampers, or dust-catchers of the flue, are shut, the whole parcel of ore (viz. 30 cwt.) is run by wheel-barrows on the flat top of the furnace; when, having been equally spread into an even surface, the proper proportion of salt and lime is sifted over it, and the whole is turned and worked with iron rakes and crooks, in every direction, until the whole is perfectly and equally mixed. Thus prepared, it is spread into a square surface, and marked into equal divisions, which, in due succession, are let down (in 8 cwt. parcels) on the upper hearth, by means of a funnel, which opens upon it through the lower vault or floor of the furnace. On this hearth it must be spread and extended equally, that the moisture of the stamp or halvan ore may be expelled, before it is shoved down on the lower hearth: after which the upper hearth is immediately filled again with another quantity, that exsiccation and calcination may be performed at the same time, by the same fire.

In the calcination, the following phenomena take place: on the surface of the picked and halvan ores, when brought on the lower hearth, and stirred, an undulating motion is observed, and a volatile sulphureous acid smell is perceived; after which the sulphur begins to disengage itself, burning, covering the whole (when the ores are very sulphureous) with a blue flame, and flying off at last in the form of a whitish thick suffocating smoke.

Whilst the sulphur is thus disengaged and decomposed in a low or gentle fire, the sulphuric acid, thence produced, decomposes the common salt, combines with its soda, and disengages the muriatic acid, which presently unites with the alkaline and metallic earths. At this time the ore begins to clot, to rise, extend, and increase in bulk and surface. It begins to look like wet ashes, and to diffuse a mixed, sulphureous, saline, acid smell, which proceeds from a lighter whitish or grayish blue smoke flying off from the surface.

From this instant the fire and furnace may be kept a little brighter, yet the ore must be continually stirred and turned over from one side of the furnace to the other; otherwise it would be calcined unequally, and some particles would remain undecomposed. If the furnace and fire were kept too bright, the sulphur, arsenic, and saline acid particles, too briskly expelled, would unavoidably carry along with them, and volatilize, many other, nay even metallic particles.

When the sulphur begins to disengage, the ore changes its colour; it changes again when the calcination is over at its rising and subsidence. The sulphureous acid smell disappears, when the ore that had been rising begins to sink, and the clotting ceases, for then part of the muriatic acid flies off. On taking a ladle full of it for proof, or even on smelling the whitish rarefied smoke near the back door of the furnace, the smell of pure muriatic acid is perceived.

Most ores and mixtures of ores, chiefly when containing a great proportion of pyrites, or when there happens to be a sulphuretted copper ore, show at this period a luminous phosphoric appearance, when suddenly taken from the hearth, and immediately examined in the dark. In a moderate heat and cold weather, they likewise show, during the stirring, bright luminous sparks, flying and scattering about like fire-works.

When the sulphur is sufficiently expelled, and part of the muriatic acid is gone; when the whole begins to subside, and the clotting to be less; and when all the above-mentioned phenomena have appeared, then the calcination is deemed to be perfect.

The colour of the calcined ores and halvans is generally red, reddish gray, dark red, or red-brown, according to the proportion of the earthy and metallic particles, or of the sulphur they contained. They are of a lighter and higher red when very earthy; brown when very coppery, or mixed with manganese; and yellowish red when lead prevails in their mixture.

Copper mixtures, containing a much greater proportion of sulphur, must undergo a longer calcining heat than other mixtures of ores and halvans. When mixed with lead, or antimony, and arsenic, they must be put to calcine not only with common salt, but also with a proportionate quantity of quick-lime, that the excess of muriatic acid may be taken from the muriats of antimony and arsenic, and from the plumbum corneum, which are produced during the calcination, and be absorbed by the lime, which prevents the untoward clotting of the particles.

The same cautions must be observed in the calcination of the mixtures of base metals and semimetals, and of the silvery black coppers, for they also contain a considerable proportion of antimony and arsenic. If not calcined with lime, along with the common salt, they pack at the very instant the antimony and arsenic are oxided and volatilized in the form of a white very thick smoke, which is brought about very expeditiously by the disengaged muriatic acid.

The mixtures of metals and semimetals and the black coppers, containing little or no sulphur, the common salt calcined with

them is decomposed by the action of the fire The muriatic acid, thus set free, promotes their oxidation, and forms with their oxides different perfect or imperfect neutral salts, disengages the disguised gold and silver particles, while the soda remains free and in a caustic state: for, in the dry way, the muriatic acid leaves its alkali, and combines with the metals and their oxides; but, by subsequent solution in water, it returns to the alkali, forming again with it common salt, and consequently lets go the metals, semimetals, and earthy particles, before in solution.

In the calcination of these metallic mixtures and the black coppers, the before-mentioned luminous phosphoric appearance does not take place; but the flame which passes over them affects various colours, and in particular the red and blue, both owing to volatilized particles of copper.

When antimonial stone, black copper, and mixtures of metals and semimetals, are put to calcine, the antimony oxides first, forming a white oxide in the flues and other passages; arsenical mixtures diffuse a white smoke and garlic smell; those which abound in lead and zinc (which last require a stronger and longer fire) produce saturnine zincous smoke, and white flowers.

When the calcination of these metallic mixtures is perfected, and the remainder is cooled, their oxides appear brownish gray, or dark gray; and those of the stone and copper mixtures of a more or less saturated red colour, except those which abound in lead.

The surest symptoms, however, of their perfect calcination, are, collectively, the rising and sinking of the mixtures, their colour, and the acrid smell of the muriatic acid. Then only the gold and silver particles may be deemed to be fully disengaged.

Sifting and grinding after calcination.

The grinding and sifting of the stuff is as necessary after as before calcination, because the stamp and halvan stuff, which is mixed up with the picked ore, could not be sifted or ground previous to its calcination, on account of its moisture. This further grinding and sifting serves likewise fully to pulverize and equalize the clots of the mixtures of metals and semimetals.

If these coarser particles were suffered to remain as they are, they might still disguise many gold and silver particles, and guard them against amalgamation.

This repeated grinding and sifting may be dispensed with when the whole stuff is of an equal size, and sufficiently fine; but its clots will at any rate require examination, whether they be soluble in water or not, for those of leady and metallic mixtures remain insoluble. If soluble, and not leaving sharp coarse particles between the fingers, they want neither grinding nor sifting, but they must go through both these operations when insoluble, and when they betray such coarse particles on being rubbed between the fingers.

Trituration, boiling, and amalgamation of the calcined stuff.

By amalgamation we understand that mechanical and chemical operation, in which, by means of quicksilver, heat, uninterrupted motion, and successive contact of the particles, gold and silver (previously disengaged from their disguises, by calcination and pulverization,) are extracted from their earthy, metallic, or mineralized matrices, and combined with quicksilver.

If the ores have been duly pulverised, and calcined, the success of trituration or amalgamation mostly depends on the proper proportions of the quicksilver and water which are added to the stuff: it likewise depends on the goodness and construction of the stirring apparatus, by which the whole mixture is kept in constant motion and mutual contact Even the degree of heat, and the quickness of the trituration or stirring, contribute to the quicker and perfect amalgamation.

To determine the quantity of quicksilver, the weight and bulk of the calcined stuff are to be considered. The lighter the stuff, the more voluminous it will prove, and consequently the gold and silver will be the more dispersed. In this case the quantity of quicksilver must be proportioned to the mass. Thus, for example, 2 cwt. of picked ore and halvans are more bulky than 2 cwt. of calcined copper or other mixtures. The former, therefore, require a larger quantity of quicksilver.

Both in small and great operations, experience has determined, that an excess of quicksilver is never hurtful, and that, on the contrary, a scanty proportion is attended with loss. It may be taken in the proportion of one to two, that is 1 cwt. of quicksilver, to 2 cwt of stuff. In this proportion, it does not increase the cost of washing and pressing, nor is any loss of quicksilver incurred; the full produce of noble metal is thus secured, and the residuum is left poorer.

The vessels or boilers, in which the quicksilver and stuff are triturated, are

of copper, of an inverted conical form, and with a concave bottom. No boiling heat required: a heat of 50° or 60° is sufficient.

No more water is required, than will soak into, and make the stuff liquid. Excess of water, makes the quicksilver sink too fast, and keeps the lighter and finer particles of the metals floating on the surface; which of course prevents the perfect success of the operation. On the other hand, too little water leaves the stuff too thick, which makes the stirring very troublesome; moreover, the evaporation of the water, soon forms a dry and hard crust, on the sides of the boiler, which is attended with loss of silver in the residuum. Experience must determine the proper respective measure of water.

The stirring apparatus is put into motion by means of a water-wheel.

The stirrers or stirring-racks (which were at first made of copper, but have since been found to answer better when made of wood) are circular segments, corresponding with the sides and bottom of the boiler.

Experience only can determine how long the respective stuffs must be triturated with quicksilver. It has been found, that some stuff yields its gold and silver to the quicksilver, perfectly and completely within eight or ten hours; other mixtures require a trituration of 12 or 15 hours. Excess of time or longer trituration, is never hurtful; too little of it will often lessen the produce.

Washing of the triturated leavings, or residuum.

The object of the trituration already described was to unite the gold and silver particles of the calcined stuff, into an amalgama with quicksilver: the object of this washing, is the separation of this rich amalgama, from the leavings or residuum.

This washing is performed in a large tub, of a conical form, with a rake within it, contrived so as to be thrown into a rotatory motion, by a water-wheel, or by hand; with side cocks for drawing off the water; and with a bottom cock for tapping off the amalgama or quicksilver.

The particles of quicksilver and amalgama, kept floating in the whole liquid mass, by the continual rotation of the rake, sink by their gravity, and collect in the concave bottom of the tub, above the cock; but the remaining stuff or ore, and stony matter, being much lighter, is kept floating. When the whole has been sufficiently stirred about in this manner, with the water, the bottom cock of the washing tub is opened, and the quicksilver and amalgama are thereby let out; after which one (or more) of the side cocks (which are fixed at different heights) is opened to let out the thin liquid stuff.

Eliquation of the quicksilver and amalgama.

The quicksilver, triturated with rich stuffs, is strained through a kind of filtrum, for the purpose of bringing the gold and silver particles into a smaller compass, and of separating them from the excess of quicksilver; although the whole can never be separated but by fire.

This is done by means of a box, on the circular opening of which lies an iron ring, to which is fixed a bag of linen damask. The quicksilver (its surface having been previously cleansed with a sponge from any muddy water, or stuff that might adhere to it) is poured in small quantities into this bag by one person, whilst another presses it with his hands, until the ball of amalgama, collecting and forming apace, no longer yields any quicksilver. When the ball becomes too big for pressure, with two hands, it is taken out, and another is formed in the same manner, until all the quicksilver has gone through the bag. The balls of amalgama are put into a wooden box.

The quicksilver which has been strained through the bag (and which always contains from twenty to thirty penny-weights of gold and silver per cwt.) is collected in a reservoir under the box, and serves again for trituration, with fresh quantities of ore.

Heating and sublimation or distillation of the amalgama.

The amalgama balls, obtained by pressing or eliquating the quicksilver, consist (according to the different degrees of pressure, they underwent) of one part silver, and four, five, or six parts quicksilver. This is expelled from them by fire in close vessels. It is a distillation *per descensum*, performed in large cast-iron pots, put over each other. The fire is kept up for five or six hours. The heat acting through the pots on the amalgama, volatilizes the quicksilver, which rising in the form of vapour, and finding no passage in the inverted upper pot, is forced down into the lower one, and collects there by the way of distillation, being condensed and precipitated by the coolness, that is constantly kept up, by cold water applied to the outside of the lower pot or receiver.

When no copper has been revived, and

the amalgama has been perfectly treated, all the quicksilver is recovered without loss, and the balls are white like silver, and mossy on their surfaces. If coppery, they have a reddish cast; and are brownish, if the copper had undergone a superficial oxidation. If leady, which is seldom the case, they show a dark pearl-gray colour.

Refining and cupellation of the silver.

The amalgama, according to their coppery or leady appearance, or to their purity, are either refined by cupellation, or simply melted down, and run into ingots.

When containing no gold, they may be delivered to the mint, without further fusion or cupellation, notwithstanding their copper alloy; but if auriferous and coppery, then they must be refined, or put to cupellation, that the copper may be destroyed, and the auriferous silver be brought to the standard of 15 loth, 15 grains *per marc*, in which it is received at the mint.

Distillation of the quicksilver, separated from the amalgam by heat or pressure.

The quicksilver, separated by heat from the amalgam, contains some of the noble metals, which passed with it through the pressing-bag. This generally amounts to three quarters of an ounce, or one ounce per cwt. But this quicksilver being constantly on hand, and always serving in the subsequent triturations, its contents of gold and silver, need only to be ascertained once at the annual balance of the accounts. This may be done, in small assays, by distilling the quicksilver, with granulated lead, in glass retorts; but the operation succeeds best, in tubulated iron retorts, with cast-iron receivers, filled with water, and luted to the necks of the retorts. Each of these is sunk half into the furnace, with its neck much inclined into the receivers. They are filled with two cwt. of quicksilver, to which is added, half a pound or a pound of granulated lead. The tubulated opening of the retort, and the neck of the receiver, must be carefully luted with refractory clay. The fire should be brisk, and the whole body of the retort be covered with the burning fuel. The quicksilver rises up in the form of vapour, and passes over into the receiver, where it is condensed, collected into drops, and falls to the bottom of the water. All the auriferous silver remains behind, united with the lead, which, if it should stick to the bottom of the retort, may be melted in it by a coal-fire, and poured out into an ingot, to be afterwards put to the test or cupellation.

Further treatment and use of the triturated residua, which have gone through the process of amalgamation.

The residua commonly contain some gold and silver, more or less, according as they were well or badly pulverized, oxided, sifted, triturated and washed. If the residuum should contain more than one ounce per cwt., and raw unoxided particles appear in the same, it will be advisable to oxide it once more, with an addition of four per cent. of salt, and to let it undergo a second amalgamation. If it should be of an equal size, and perfectly oxided, it should be mixed up with new stuff, or triturated once more alone.

If, on the contrary, the residuum is silvery, in consequence of the imperfect washing and separation of the quicksilver and amalgam, it must be washed over again, more abundantly diluted with water.

The lixivia containing copper, are precipitated by iron.

The Editors of the Chemical Journal add the following remarks, in a note, on the cold amalgamation:

Considering the complex apparatus for the warm amalgamation, the wear and loss of the copper boilers, the unequal produce, and the expense of firing, (all which are now avoided) the cold amalgamation is, as Mr. Raspe observes, a noble improvement of the process. It is what baron Born always aimed at, though his attempts were unsuccessful. Mr. Gellert, at Freyberg, first succeeded in it, using wooden cylindrical churns, with perpendicular pistons, laid over with copper sheeting, which, by a quick motion up and down, produce a stronger trituration than the rotatory horizontal motion of barrels, and at the same time, prevents the possibility of producing sublimate, or mercurius dulcis, by the excess of muriatic acid, acting upon the quicksilver, to which that acid has less affinity than to copper.

His first experiment, was attended with uncommon success; for, by cold churning, he extracted the silver from pulverised ore, which contains but three ounces and a quarter per quintal, in the course of sixteen hours, so completely, that the leavings contained but two dwts. (The operation may even be finished in ten hours, whilst others required twenty-four.) Upon these principles, the churning apparatus, in wooden cylinders, has been adopted in Bohemia, with a perforated cast-iron piston, which, by a crank

motion, moves quickly up and down. Though the whole is put in cold, yet, at the end of the operation, it heats, in consequence of the quick trituration and motion of the pistons.

At Freyberg, this cold amalgamation is performed in a mill, which turns eight large barrels, each holding ten and an half quintals of ore. The ores are dressed to contain four ounces per quintal, mixed with 10 per cent. of salt, and calcined and sifted in baron Born's manner. When put into the barrels, one-fourth per cent. of quicklime, and 34 lbs. of water are added, and turned briskly two hours, thirty-six turns per minute. The lime absorbs the excess of acids. To counteract the decomposition of metallic sulphats, and the precipitation of silver particles, (which an excess of lime might occasion) after two hours turning, two per cent. of thin rolled iron chips, two inches square, are thrown into the barrels, and turned with the same two hours. Then the quicksilver, half a quintal to one quintal of ore, is added, together with an additional four per cent. of iron chips, previously coated with a little copper, by immersion in copper water, in order to prevent the dispersion of the quicksilver, and to catch and attract its smallest particles. After the last coppery-iron chips, and the quicksilver have been added, the barrels are turned slower, at the rate of twenty or twenty-five turns per minute. After twelve hours turning, all the silver is extracted, except one and a quarter dwt. per quintal, which cannot be farther extracted by amalgamation.

Ores of Iridum.

This metal has been found hitherto only in the black powder left, after dissolving platina.

Ores of Iron.

When we consider the great destructibility of iron, by the disengaged acids, and other uncombined agents in nature, it is not to be expected, that much native iron should be found. We have, however, indubital accounts of its existence in various parts of the world. The most remarkable mass of this sort, was discovered in Siberia, by professor Pallas, which weighed 1600 pounds. Specimens of this have been sent to all parts of Europe. It is of that species called red short, being malleable while cold, but brittle when red-hot. This has lately been classed with the stones called meteoric. See the conclusion of the article METEOROLOGY

Bergman considers mispickle, as a mixture of native iron and arsenic. It is called Pierre de Santé by the French, but for what reason I know not, and is cut for toys. Thirty or forty years ago, a mineral was in common use, for this purpose in England. The small stone or pieces were called marcasites, and were, I suppose, mispickel.

The magnet, or loadstone, is an ore containing iron, approaching to the metallic state. It has not been much examined, probably on account of the heterogeneous nature of the various stones called by this name. Magnetism is their characteristic property, but they may nevertheless differ exceedingly in their contents, so as scarcely to come under the same mineralogical arrangement. Some contain as much as 75 per cent. of iron. See MAGNETISM.

The black iron ore, or steel ore, is ponderous, of a very dark gray colour, or rather slate black, and affords a black powder when scraped. Some specimens, however, afford a red powder. It is readily attracted by the magnet. Its fracture exhibits grains more or less fine, or else scales or facets, whence it has been improperly called galena of iron. When exposed to heat, it gives scarcely any smell, and changes its colour very little, though its shining appearance goes off. A strong heat renders it partly malleable. It gives fire with steel, in consequence of a proportion of quartz it contains. Acids act upon it to a certain degree, but the iron is too much oxided to afford many crystals with the sulphuric acid.

That species of black iron ore, which has the form of octahedrons, nearly resembles the foregoing in its properties.

The ochres are very common, and appear to have been produced, by the decomposition of pyrites; see OCHRES. There are two varieties ; 1. Yellow ochre: this becomes red by calcination. 2. Red ochre. Both these are so common, and so much used in the arts, that it is scarcely requisite to describe the great variations of colour and consistence, the several specimens possess.

Earthy, argillaceous, or bog ores of iron, are of different colours, reddish, yellowish, brown, and sometimes gray, especially after exposure, to the air for a time. Internally they have a blueish gray, or iron colour This ore is brittle, and resembles scoriæ, or small rounded or flattened stones, not obedient to the magnet, and in general of inconsiderable hardness It mostly abounds with foreign sandy, argillaceous, or calcareous matters.

The crystallized iron ore of the island of Elba is one of the most beautiful of minerals. It has not yet been found ex-

cept in that island. It is found in different states, in ochres of every shade, in the argillaceous sandy ore, in crystallized ore, and in hematites. The crystallized is the most common, the purest, and most beautiful. Its form, as well as colour, varies much. The shades are green, red, black, yellow, brown, blue, and violet; and some exhibit all the various and lively colours of precious stones, though this brilliant appearance becomes tarnished by the moisture of the air. This ore is very ponderous and hard, and frequently mixed with copper pyrites. Acids do not attack it, neither is it affected by the magnet, at least while in the mass: we do not find that this ore has been well analysed. Some writers pretend, that sulphur is the mineralizer, and others, carbonic acid; but from its great resemblance to the combination of iron with water in the experiment of the gun-barrel, it appears likely that that fluid, as one of its principles, enters into the iron ore of the isle of Elba.

Hematites exists in considerable abundance in the iron mines of ancient formation. It is formed in the manner of stalactites and stony concretions. In general it possesses considerable hardness, so as sometimes to give fire with steel. The varieties are,

1. Blackish hematites; fracture, vitreous, and sometimes shining; texture, fibrous or striated; colour, brown black, but reddish when pounded. It gives fire with steel, becomes darker coloured, and as it were scaly, by ignition.

2. Red hematites. This is chiefly entitled to the name of blood-stone, from its colour. It is very heavy, ponderous, striated, and as if crystallized, or in small globules, called kidney-ore.

3. Yellow hematites. This differs from the preceding, from the degree of the oxidation of its metallic part, in the same manner as yellow ochre differs from red.

The specular iron ore, mentioned by Mongez among the oxides of iron, is easily distinguished by its brilliant facets, which often resemble polished steel. It is distinguished from the iron ore of Elba by a small portion of sulphur, which it contains. It is plentifully found at Mount d'Or in Auvergne.

Emery was considered as an ore of iron, which has the appearance of a very compact granular stone, of a blackish, grayish, or brown colour. By calcination it becomes brown or red, and, as Mongez says, harder than before. It is used as a grinding and polishing powder, and is scarcely inferior in hardness to any substance but the diamond. Its specific gravity is from 3.008 to 4.000. The best sort is of a dark gray colour. It is never wrought as an iron ore. Late experiments appear to have classed it with CORUNDUM.

The white or sparry iron ore, or stahlstein of the Germans, consists, according to Bergman, of the brown oxide of iron united with the white oxide of manganese, and carbonat of lime, in various proportions. Bayen examined a specimen from Germany of the best steel ore, and found it to contain two thirds iron, and the rest carbonic acid, except a small portion of zinc. The figure of this ore is either irregular or rhomboidal; frequently transparent; its texture scaly, lamellar, granular, or cellular. Sometimes it possesses a stalactitical form, and is sometimes found in a blackish brown powder. Its colour, when fresh dug, is whitish, but by exposure to the air it becomes gray, brown, reddish, yellowish, or black. Its specific gravity is from 3.6 to 4.0. It does not give fire with steel, unless by virtue of particles of quartz or pyrites, with which it is frequently interspersed. In the fire it decrepitates, grows black, becomes magnetic, and loses about one third of its weight by the extrication of carbonic acid. One hundred parts of this ore from Eisenartz in Stiria, afforded Bergman 38 of the brown oxide of iron, 24 of the white oxide of manganese, and 38 of carbonat of lime. The iron answering to this quantity of oxide is about 32 parts, or one third of the whole.

Iron mineralized by sulphur is mostly distinguished by the name of pyrites. It seldom contains iron in sufficient quantity to be extracted with profit, not only because a long continued heat is required to drive off the last portions of sulphur, but likewise because the iron usually proves of a bad quality. This ore has various degrees of hardness and consistency; is of a pale yellow colour, sometimes approaching that of gold, a circumstance which, added to its considerable weight, often attracts the attention of the unskilful, who imagine it to contain gold. It gives plenty of sparks with the steel, and emits an odour of sulphur. In the fire it cracks or decrepitates, burns with a blue flame, and assumes a dull brown colour: in the air it effloresces, is decomposed, its sulphur becomes acidified, unites with the iron and clay which are present in its composition, and with these forms sulphat of iron and alum, for the obtaining both of which this mineral is wrought. Its varieties are,

1. In irregular masses.

2. In balls of various sizes disseminated in chalk.

3. In stalactites.

4. In cubes, frequently found in clay.

5. In hard crystals called marcasite.

The brown or reddish-brown ferruginous pyrites is called the hepatic iron ore. It is either spherical, or in cubes, or other regular forms; has no metallic lustre, does not easily give fire with steel, and is incapable of being converted to a sulphat. It contains much less sulphur and more iron than the yellow pyrites, but the metal it yields is brittle.

Gray iron ore has a shining metallic appearance, and commonly gives fire with steel. It is not at all magnetic, and, when scratched, gives a red trace. It yields from 40 to 66 per cent. of cold short iron. This property is derived from phosphorus, or its acid, which exists in the ore.

Plumbago is a carburet of iron.

A cupreous arseniat of iron, in very brilliant and transparent crystals, of a faint sky-blue colour, has been described by the count de Bournon, and analysed by Mr. Chenevix. It contains, in 100 parts, oxide of iron 27.5, oxide of copper 22.5, arsenic acid 33.5, silex 3, water 12. Specific gravity, 3. 4. Another, in which Mr. Chenevix considers the copper as merely accidental, was of a dark green, with a brownish tinge, and sometimes yellowish; tolerably transparent; and scarcely so hard as the preceding, being barely able to scratch calcareous spar. This gave oxide of iron 45.5, oxide of copper 9, arsenic acid 31, silex 4, water 10.5. Specific gravity 3. They were both from Cornwall.

A blue combination of iron is found interspersed in clays, in Finland, Scania, and elsewhere. Bergman calls it Native Prussian Blue. Sometimes the clays have a blue colour at the surface, and sometimes they assume that colour soon after being dug out of the ground. It is easily seen, that the ore is ferruginous, and highly loaded with combustible matter; for it burns with a flame, and becomes red and magnetical. A mild heat renders this substance green, and a stronger converts it into black scoria. Alkalies, as well as acids, dissolve this blue powder, and destroy its colour, which nevertheless appears again when precipitated from an acid by an alkali, or by an alkali from an acid; but commonly it is greenish, and soon becomes white. If an infusion of tea or nut-galls be poured on this whitish sediment, it resumes its first colour. From these details it appears, as Bergman remarks, that this blue, though analogous to the artificial Prussian blue, differs nevertheless from it in intensity, by the manner of its production, and other peculiar qualities. It preserves its colour in water, but becomes black in oils.

For the methods of analysis of the ores of iron, as well as its chemical properties and several states, see the article Iron. But from the extensive importance of this metal, we shall here add the methods of treatment in the large way.

Most ores of iron require to be roasted previously to their fusion; some more slightly, and others with a more violent and longer continued fire. Those which contain much sulphur, arsenic, or sulphuric acid, require a long continued and repeated roasting, that the volatile matters may be expelled. Of this kind is the black iron ore, from which the Swedish iron is said to be obtained.

Some ores require a very slight roasting, only that they may be dried and rendered friable; such are the ores called bog ores: and others, which being in an oxided state, and containing little sulphureous matter, would, by a farther oxidation, be rendered less capable of being reduced to a metallic state.

The roasting of ores of iron is performed by kindling piles, consisting of strata of fuel and of ore placed alternately upon one another, or in furnaces similar to those commonly employed for the calcination of limestone.

The next operation is the fusion or smelting of the ore. This is generally performed in blast furnaces or towers from twenty to thirty feet high, in the bottom of which is a basin for the reception of the fluid metal. When the furnace is sufficiently heated, which must be done at first very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of lime-stone, or whatever other flux is employed. While the fuel below is consumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, sink gradually down, till they are exposed to the greatest heat in the furnace. There the ore and the flux are fused, the metallic particles are revived by the fuel, precipitated by means of their weight through the scoriæ formed of the lighter earthy parts of the flux and of the ore, and unite in the basin at the bottom of the furnace, forming a mass of fluid meta , covered by a glassy scoria. When a sufficient quantity of this fluid metal is collected, which is generally twice or thrice

in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of sand; and thence into smaller lateral or connected channels, or other moulds. There it is cooled, becomes solid, and retains the forms of the channels or moulds into which it flows.

The piece of iron formed in the large channel is called a sow, and those formed in the smaller channels are called pigs. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of sand or of clay, and is thus formed into the various utensils and instruments for which cast iron is a proper material.

The scoria must be from time to time allowed to flow out, when a considerable quantity is formed, through an aperture made in the front of the furnace for this purpose. A sufficient quantity of it must, however, be always left to cover the surface of the melted iron; else the ore which would fall upon it, before the separation of its metallic from its unmetallic parts, would lessen the fluidity and injure the purity of the melted metal. This scoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, or be precipitated. Accordingly, a scoria, not sufficiently fluid, is always found to contain much metal. If the scoria be too thin, the metallic particles of the ore will be precipitated before they are sufficiently metallized, and separated from the earthy and unmetallic parts A due degree of fluidity is given to the scoria, by applying a proper heat, and by adding fluxes suited to the ore.

Some ores are fusible without addition, and others cannot be melted without the addition of substances capable of facilitating their fusion.

The fusible ores are those which contain sulphur, arsenic, or are mixed with some fusible earth.

The ores difficultly fusible are,

1. Those which contain no mixture of other substance. Such are most of the ores which contain iron in a state nearly metallic. As iron itself, when purified from all heterogeneous matters, is scarcely fusible without addition, so the metal contained in these purer kinds of ores cannot be easily extracted, without the addition of some fusible substance.

2. Those which are mixed with some very refractory substance. Some of these refractory ores contain arsenic; but as this substance facilitates the fusion of iron, we may presume, that their refractory quality depends upon a mixture of some unmetallic earth or other unfusible substance. The earth which is mixed with the common calciform ores is in considerable quantity, and is sometimes calcareous, sometimes siliceous, and sometimes argillaceous. Most of the iron stones wrought in this country have a mixture of all three, but in variable proportions, and according as one or other is predominant, a greater or less proportion of flux is required.

Keir thinks it probable, that the fusibility of some ores may greatly depend on the degree of oxidation to which the metal contained in them has been reduced; since we have reason to believe, that, by a very perfect oxidation, some metals, at least, may be reduced to the state of being almost infusible, and scarcely capable of reduction; and since we know, that in every oxidation and subsequent reduction of a given quantity of any imperfect metal, a perceptible part of that quantity is always lost or destroyed, however carefully these operations may have been performed. That some of these ores are already too much oxided, appears from the instance above mentioned of the bog ores, which are injured by roasting; and even the great height of the common smelting furnaces, although advantageous to many ores that require much roasting, is said to be injurious to those which are already too much oxided, by exposing them to a farther oxidation, during their very gradual descent, before they arrive at the hottest part of the furnace, where they are fused.

But, as too violent calcination renders some ores difficultly fusible; so too slight calcination of other ores injures the purity of the metal, by leaving much of the sulphureous or other volatile matter, which ought to have been expelled.

Various substances are added to assist the fusion of ores difficultly fusible. These are:

1. Ores of a fusible quality, or which, being mixed with others of a very different quality, become fusible: accordingly, in the great works for smelting ores of iron, two or more different kinds of ores are commonly mixed, to facilitate the fusion, and also to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called red-short, and another ore which produces iron brittle when cold, or cold-short, are often mixed together; not, as is sometimes supposed, that these qualities are mutually destructive of each other, but that each of them is diminished in the mixed mass of iron, as much as

this mass is larger than the part of the mass originally possessed of that quality Thus, if from two such ores the mass of iron obtained consists of equal parts of cold-short and of red-short iron, it will have both these qualities, but will be only half as cold-short as iron obtained solely from one of the ores, and half as red-short as iron obtained only from the other ore.

2. Earths and stones are also generally added to facilitate the fusion of iron ores. These are such as are fusible, or become fusible when mixed with the ore, or with the earth adhering to it. Authors direct, that, if the earth of the ore be of an argillaceous or siliceous nature, lime-stone or some calcareous earth should be added; and that if the adherent earth be calcareous, an argillaceous or siliceous earth should be added; because these two earths, though singly infusible, yet, when mixed, mutually promote the fusion of each other: but we believe limestone is the only addition ever made, beside the fuel.

The fuel generally used on the continent of Europe for smelting ores of iron is charcoal: but in almost all the works in England and Scotland, iron ore is smelted by means of pit-coal, previously reduced to cinders or coke, by a kind of calcination similar to the operation for converting wood into charcoal. In France, pit-coal not charred has been tried for this purpose, but unsuccessfully. The use of peat has also been introduced in some parts of England.

The quality of the iron depends considerably upon the quality, and also upon the quantity, of the fuel employed. Charcoal is fitter than coke for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intensity of the heat, must be suited to the greater or less fusibility of the ore. Sulphureous and other ores easily fusible require less fuel than ores difficultly fusible. In general, if the quantity of fuel be too small, and the heat not sufficiently intense, all the iron will not be reduced, and much of it will remain in the scoria, which will not be sufficiently thin.

This defect of fuel may be known by the blackness and compactness of the scoria, by the qualities of the iron obtained, which in this case is hard, white, light, intermixed with scoria, smooth in its texture, without scales or grains, rough and convex on its surface, and liable to great loss of weight by being forged; and lastly, it may be known by observing the colour and appearance of the drops of metal falling down from the smelted ore, and of the scoria upon the surface of the fluid metal, both which are darker coloured than when more fuel is used.

When the quantity of fuel is sufficiently large, and the heat is intense enough, the iron is darker coloured, denser, more tenacious, contains less scoria, and is therefore less fusible, and loses less of its weight by being forged. Its surface is also smoother and somewhat concave; and its texture is generally granulated The scoria in this case is of a lighter colour and less dense. The drops falling from the smelting ore, and the liquid scoria in the furnace, appear hotter and of a brighter colour

When the quantity of fuel is too great, and the heat too intense, the iron will appear to have a still darker colour, and more conspicuous grains or plates; and the scoria will be lighter, whiter, and more spongy. The drops falling from the smelted ore, and the fluid scoria, will appear to a person looking into the furnace through the black hole to be very white and shining hot.

The quantity of charcoal necessary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation skilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumstances. Mr. Mushet calculates, that, if a calcined iron stone affording 40 per cent. of iron, 1 cwt. of coke from clod-coal will smelt 130 lbs. producing 52 lbs. of iron; 1 cwt. of coke from splint coal, 105 lbs. yielding 42 lbs. of iron; and 1 cwt. of coke from hard and soft coal mixed, 84 lbs. giving 33.6 lbs. of iron.

The time during which the fluid metal ought to be kept in fusion, before it is allowed to flow out of the furnace, must be also attended to. In some works the metal is allowed to flow out of the furnace every six or eight, and in some others only every ten or twelve, hours. Some workmen imagine, that a considerable time is necessary for the concoction of the metal. This is certain, that the iron undergoes some change by being kept in a fluid state; and that, if its fusion be prolonged much beyond the usual time, it is rendered less fluid, and also its cohesion, when it becomes cold, is thereby greatly diminished. The quantity of iron daily obtained from such a furnace as is above described, is from two to five tons, according to the richness and fusibility of the ore, to the construction of the furnace, to the adjustment of the due quantity of flux and of fuel, and to the skill employed in conducting the operation.

The quality of the iron is judged by observing the appearances during its flowing from the furnace, and when it is fixed and cold. If the fluid iron, while it flows, emits many and large sparkles; if many brown spots appear on it while it is yet red-hot; if, when it is fixed and cold, its corners and edges are thick and rough, and its surface is thick and spotted; it is known to have a red-short quality. If, in flowing, the iron seems covered with a thin glassy crust, and if, when cold, its texture be whitish, it is believed to be cold-short. Reaumur says, that dark-coloured cast-iron is more impure than that which is white. The marquis de Courtivron is of a contrary opinion.

But no certain rules for judging of the quality of iron before it is forged can be given. From brittle cast-iron sometimes ductile forged-iron is produced. Cast-iron with brilliant plates and points, when forged, becomes sometimes red-short, and sometimes cold-short. Large shining plates, large cavities called eyes, want of sufficient density, are almost certain marks of bad iron; but whether it will be cold or red-short, cannot be affirmed, till it is forged. Whiteness of colour, brittleness, closeness of texture, and hardness, are given to almost any cast-iron by sudden cooling; and we may observe, that in general, the whiter the metal is, the harder it is also, whether these properties proceed from the quality of the iron, or from sudden cooling; and that, therefore, the darker-coloured iron is fitter for being cast into moulds, because it seems capable of being filed and polished, especially after it has been exposed, during several hours, to a red heat in a reverberatory furnace, and very gradually cooled. This operation, called by the workmen annealing, changes the texture of the metal, renders it softer, and more capable of being filed than before, and also considerably less brittle.

It is in fact capable of being softened by annealing, and hardened by sudden cooling like steel, through the heat regained, for these changes are greater. Many artists avail themselves of this property to advantage. See IRON.

In Navarre, and in some of the southern parts of France, iron ore is smelted in furnaces much smaller, and of a very different construction from those above described. A furnace of this kind consists of a wide-mouthed copper caldron, the inner surface of which is lined with masonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form The space or cavity contained by the masonry is the furnace in which the ore is smelted. The depth of this cavity is equal to two feet and a half; the larger diameter of the oval mouth of the cavity is about eight feet; and its smaller diameter is about six feet: the space of the furnace is gradually contracted towards the bottom, the greatest diameter of which does not exceed six feet: eighteen inches above the bottom is a cylindrical channel in one of the longer sides of the caldron and masonry, through which the nozzle of the bellows passes. This channel, and also the bellows-pipe, are so inclined, that the wind is directed towards the lowest point of the opposite side of the furnace. Another cylindrical channel is in one of the shorter sides of the furnace, at the height of a few inches from the bottom, which is generally kept closed, and is opened occasionally to give passage to the scoria; and above this is a third channel, in the same side of the furnace, through which an iron instrument is occasionally introduced to stir the fluid metal, and to assist, as is said, the separation of the scoria from it The greatest height of this channel is at its external aperture on the outside of the furnace, and its smaller height is at its internal aperture, so that the instrument may be directed towards the bottom of the furnace; but the second channel below it has a contrary inclination, that when an opening is made, the scoria may flow out of the furnace into a bason placed for its reception.

When the furnace is heated sufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previously roasted. They take care to throw the charcoal chiefly on that side at which the wind enters, and the ore at the opposite side. At the end of about four hours a mass of iron is collected at the bottom of the furnace, which is generally about six hundred weight; the bellows are then stopped; and when the mass of iron is become solid, the workmen raise it from the bottom of the furnace, and place it, while yet soft, under a large hammer, where it is forged. The iron produced in these furnaces is of the best quality; the quantity is also very considerable, in proportion to the quantity of ore, and to the quantity of fuel employed. In these furnaces no lime-stone or other substance is used to facilitate the fusion of the ore

We should receive much instruction concerning the smelting of iron ore, if we knew upon what part of the process or circumstance the excellence of the iron obtained in these furnaces depends; whether on the quality of the ore; on the disuse of any kind of flux, by which the pro-

portion of vitreous or earthy matter, intermixed with the metallic particles, is diminished; on the forging while the iron is yet soft and hot, as the marquis de Courtivron thinks; or on some other cause not observed.

To separate the impurities from cast iron, and to unite the metallic parts more closely and compactly, and thus to give it the ductility and tenacity which render this metal more useful than any other, are the effects produced by the following operations:

The first of these operations is a fusion of the iron, by which much of its impurities is separated in form of scoria; and by the second operation, a farther and more complete separation of these impurities, and also a closer compaction of the metallic particles, are effected by the application of mechanical force or pressure, by means of large hammers.

Some differences in the construction of the forge or furnace, in which the fusion or refining of cast iron is performed, in the method of conducting the operation, and in some other circumstances, are observed to occur in different places. The following is the German method:

The fusion of the cast iron, which is to be rendered malleable, is performed upon the hearth of a forge similar to that used by blacksmiths: at one side of this hearth is formed a cavity or fire-place, which is intended to contain the fuel and the iron to be melted: this fire-place is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep; it is bounded on three sides by three plates of cast iron, placed upright; and on the fourth side, which is the front, or that part nearest to which the workmen stand, by a large forge hammer, through the eye of which the scoria is at certain times allowed to flow. The floor also of the fire-place is another cast iron plate. The thickness of these plates is from two to four inches. One of the upright side plates rests against a wall, in an aperture through which a copper tube, called the tuyere, is luted with clay. This tube is a kind of case or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot farther than this pipe into the fire-place, and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is requisite to act. The tube rests upon the upper edge of the side-plate which leans against the wall, nearer to the back part than to the front of the fire-place, and in such an oblique direction, that the wind shall be impelled towards the farthest part of the floor of the fire-place, or where this floor is intersected by the opposite side-plate. The obliquity of the tuyere ought to vary according to the quality of the iron; and therefore, in every operation it may be shifted till its proper position is found. The more nearly its direction approaches to a horizontal plane, the more intense is the heat; but a larger quantity of fuel is consumed than is even proportional to the increase of heat, because the flame is not then so well confined. When the iron is easily fusible, great heat is not required; the tuyere may then decline considerably from the horizontal plane, and thus fuel may be saved. This tuyere, though made of copper, a metal more easily fusible than iron, is preserved from fusion by the constant passage of cold air through it. It must be carefully kept open, and cleansed from the scoria, which would be apt to block its cavity, by which not only the heat would be too much diminished for the success of the operation, but the tube itself would be melted.

To prepare for the fusion, a quantity of scoria of a former operation is thrown into the fire-place, till one third part of this is full; and then the remaining two thirds of the fire-place are to be filled with smaller scoriæ, coal-dust, and sparks ejected from hot iron. These matters, being fusible, form a bath for the reception of the iron when melted. Upon this bed of scoria the mass of cast iron to be melted is placed; so that one end of it shall be within the fire-place, opposite to the tuyere, and at the distance of about four or five inches from its aperture; and the other end shall stand without the fi e-place, to be pushed in as the former is melted. The upper side of the mass of iron ought to be in the same horizontal plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its course, strike upon and pass along the under side of the mass: but if the iron be difficultly fusible, the tuyere is to be disposed more horizontally, so that the wind shall strike directly upon the mass of iron; and that one part of the blast shall graze along the upper surface, and the other part along the under surface of the iron. The mass of iron weighs generally from 00 to 400 pounds. Sometimes two or three smaller masses are put one above another, so as not to touch. When these are of different qualities, the cold-short piece is placed undermost, that being less fusible than the red-short. The iron being placed, charcoal powder is thrown on both sides;

and coals are accumulated above, so as entirely to cover the iron.

The coals are then to be kindled, and the bellows are made to blow, at first slowly, and afterwards with gradually increased force. The iron is liquefied by degrees, and flows down in drops through the melted scoria to the bottom of the fire-place; during which the workmen frequently turn the iron, so that the end opposed to the blast of wind may be equally exposed to heat, and uniformly fused. While the coals are consuming, more are thrown on, so that the whole may be kept quite covered. During the operation, a workman frequently sounds the bottom and corners of the fire-place, by means of a bar or poker, raises up any mass of metal which he finds adhering to these, and exposes them to the greatest heat, that they may be more perfectly fused.

When all the iron is fused, no more coals are to be added, but the melted mass is to remain half uncovered for some time; during which the iron boils and bubbles, and its surface swells and rises higher and higher. When the iron has risen as high as the upper edge of the fire-place, the coals upon its surface must be removed; and by thus exposing it to cold air, its ebullition and swelling subside. In this state, or coction, the iron is kept during half an hour, or more, by adding occasionally pieces of good coal, which maintain a sufficient heat, without covering entirely the surface of the mass. During this coction, the workmen allow the orifice of the tuyere to be half stopped up by the scoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued sufficiently long, they clear the passage of the tuyere, and the mass is soon cooled by the cold air: at the same time also, they open a passage in the eye of the hammer placed in the front of the fire-place, through which some of the scoria is allowed to flow out. When the iron has become solid, the bellows are stopped, the coals are removed, and the mass is left during an hour: and then the workmen raise it from the fire-place, turn it upside down, and proceed to the second coction or fusion of the iron.

For this second operation, the mass is to be so placed, that one part of it shall rest upon the tuyere, and the other upon the scoria remaining in the fire-place. This scoria is to be disposed in an oblique direction, parallel to the tuyere, by which means the wind of the bellows is obliged to pass all along the under side of the mass of iron. About the sides of the mass, charcoal-powder and burnt ashes are thrown; but toward the tuyere, dry and entire pieces of coals are placed to maintain the fire. When these are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it may pass equally along under the surface of the iron, quite to the farther extremity; and that it do not escape at the sides, or be reverberated back toward the tuyere, by which this copper tube might be melted. During this fusion, pieces of iron are apt to be separated from the mass, and to fall down unfused to the bottom and corners of the fire-place. These are carefully to be searched for, and exposed to the greatest heat till they are melted When the whole mass is thus brought into perfect fusion, the coals are removed, and the wind blowing on its surface, whirls and dissipates the small remaining pieces of scoria, and sparks thrown out from the fluid iron. This jet of fire continues about seven or eight minutes, and the whole operation about two hours. In this second fusion the scoria is to be thrice removed, by opening a passage through the eye of the hammer. The first time of removing the scoria is about twenty minutes from the kindling of the fire; the second time is about forty minutes after the first; and the third time is near the end of the operation.

The mass is then removed from the hearth, and put upon the ground of the forge, where it is cleaned from scoria, and beaten into a more uniform shape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This mass is to be divided into five, six, or more pieces, by means of a wedge; and these are to be heated and forged till they are reduced to the form of the bars commonly sold.

In some forges the iron is fused only once, and in others it suffers three fusions, by which it is said to be rendered very pure. Where only one fusion is practised, it is called the French method. In this no greater quantity of iron is fused at once, than is sufficient to make one bar. The fire-place is of considerably less dimensions, and especially is less deep than in the German method above described. The fire is also more intense, and the proportion of fuel consumed to the iron is greater. The iron, when melted, is not kept in a state of ebullition, as is above described; but this ebullition is prevented by stirring the fluid mass with an iron bar, till it is coagulated and becomes solid.

By these operations, fusion and forging, the iron loses about two-thirteenth parts of its former weight, sometimes more, and sometimes less, according to the quality of the cast iron employed; its metallic particles are more closely compacted, its texture is changed, and it is rendered more dense, soft, and malleable, tough, and difficultly fusible.

The degrees, however, of these qualities vary much in different kinds of iron. Thus some iron is tough and malleable, both when it is hot, and when it is cold. This is the best and most useful iron. It may be known generally by the equable surface of the forged bar, which is free from transverse fissures or cracks in the edges; and by a clear, white, small-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called cold-short iron, and is generally known by a texture consisting of large shining plates, without any fibres. It is less liable to rust than other iron. A third kind of iron, called red-short, is brittle when hot, and malleable when cold. On the surface and edges of the bars of this kind of iron, transverse cracks or fissures may be seen; and its internal colour is dull and dark. It is very liable to rust. Lastly, some iron is brittle, both when hot and cold.

In one bar frequently two or more different kinds of iron may be observed, which run all along its whole length; and scarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together in the smelting, and also from the practice of mixing two or more pigs of cast iron of different qualities in the finery of these; by which means the red-short and the cold-short qualities of the different kinds are not, as we have already remarked, mutually counteracted or destroyed by each other; but each of these qualities is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality. For these different kinds of iron seem as if they were only capable of being interwoven and diffused through each other but not of being intimately united or combined.

The quality of forged iron may be known by the texture which appears on breaking a bar. The best and toughest iron is that which has the most fibrous texture, and is of a clear grayish colour. This fibrous appearance is given by the resistance which the particles of the iron make to their rupture. The next best iron is that, the texture of which consists of clear whitish small grains, intermixed with fibres. These two kinds are malleable, both when hot and when cold, and have great tenacity. Cold-short iron is known by a texture consisting of large shining plates without fibres; and red-short iron is distinguished by its dark dull colour, and by the transverse cracks and fissures on the surface and edges of the bars. The quality of iron may be much improved by violent compression, as by forging and rolling, especially when it is not long exposed to too violent heat, which is known to injure, and at length to destroy, its metallic properties.

In January, 1806, Mr. Descotils read to the mathematical and physical class of the French National Institute a memoir, in which he proved by experiments, that the iron spar, which was the subject of it, varied in the proportions of its constituent principles; and hence he explained the differences that the ores require in their metallurgic treatment. The difficulty of fusing some of them constituted at that time the principal object of his research; and the comparative analysis he made led him to the conclusion, that the magnesia, which is frequently found in them in large quantity, was the cause of their refractoriness.

Reflecting on the processes adopted to deprive these ores, of the principle of their infusibility, which consist chiefly in exposure to the air and rain, either before or after roasting, Mr. Descotils conjectured, that these processes had no other effect, than that of separating the magnesia.

In the first case, that is to say, when these ores were exposed to the air before roasting, he supposed, that this earth was dissolved in the state of carbonat by the rain. In the second, on the contrary, he ascribed this effect to the sulphuric acid, developed by the efflorescence of the pyrites, with which the iron spar is almost always accompanied.

Since that period, Mr. Descotils has communicated to this assembly, a second memoir, in which he furnishes substantial proofs of the explanations he has offered in the former paper, as merely conjectural; at the same time avails himself of them, to answer some objections, that had been advanced by Mr. Hassenfratz. The latter gentleman, however, after having made some fresh experiments and observations, has withdrawn his memoir, which the class has referred to the same committee: we shall not therefore enter into any discussion of the points, on which these two learned chemists differed, but shall consider the facts related by Mr. Desco-

tils, and the conclusion he has deduced from them, as if they had never been disputed.

On the second occasion, Mr. Descotils has repeated his former experiments, which gave him the same results. He has likewise made new ones; and all mutually supporting each other, have only confirmed him in his opinion. But let us relate some of these experiments.

He exposed to the fire, a mixture of 15 parts of magnesia, and 100 parts of iron ore, from the isle of Elba, finely powdered; and the result he obtained was perfectly similar to what every magnesian iron spar had furnished him.

To ascertain whether the division of the particles of the substance had any influence on its fusibility, he made a trial with part of the same specimen, of iron ore of Elba, without wasting or powdering it, and he obtained a perfectly compact button, at a degree of heat, similar to what would have been requisite, for an assay of earthy iron ore, with the addition of borax.

This fact shews, says the author, that cohesion does not diminish the fusibility of iron ores; at least, if this cohesion can be estimated, by the hardness of the ore, and the resistance it offers to the action of acids, for none possess these two qualities in a more striking degree, than the iron crystals of the isle of Elba. The committee are of a similar opinion, only the fusion must require so much longer time, in proportion as the ore is in fragments, of a larger bulk.

Mr. Descotils could have wished to analise specimens of refractory iron spar, comparatively with specimens of the same ore, become fusible by exposure to the air: but not having been able to procure any, he thought he might supply their place by two pieces, from the same vein, one of which was not altered, the other had passed to the state of a free ore.

Without describing the method he employed for this purpose, which we consider as very accurate, we shall only say, that he found the decomposed ore, no longer contained any magnesia or carbonic acid, while the other contained four per cent. of carbonic acid, and magnesia.

The analysis of five other specimens, of free ores, from different places, gave him the same results; whence he concludes, that the separation of the magnesia is complete, when the decomposition of the ores is complete.

In some cases he suspects, that it is to the efflorescence of the pyrites, from which scarcely any sparry iron ore is free, that the solution and abstraction of the magnesia of the raw ore, is owing; since sulphat of magnesia is sometimes to be observed on heaps of ore, of an analogous nature, exposed to the air, as well as in the waters, with which these ores are washed; and he has obtained similar results in a small way, by putting magnesian iron spar in powder, into a solution of sulphat of iron.

He believes, however, that it is most frequently the carbonic acid, which, disengaged from the iron, in proportion as this absorbs oxygen, dissolves and carries off the magnesia by means of water.

As to the change effected in the roasted ore, by exposure to the air and rain, the conjectures of Mr. Descotils are confirmed by analysing the waters, with which a heap of roasted ore, long exposed to the air, had been washed. These waters contained nothing but sulphat of magnesia, and a little sulphat of lime; which salts could have been produced only by the action of the sulphuric acid, arising from the pyrites, on the earthy substances contained in the ore.

Mr. Descotils quotes letters of several well-informed persons, and worthy of credit, who, in agreeing on the point, that sparry iron ores, recently extracted and roasted, are more difficult of fusion, and less productive, than those that have remained three or four years in the open air, give still more force to his theory.

Though it is certain, that the presence of magnesia in iron ores, diminishes their fusibility more or less, the author of the memoirs observes, however, that, if it be accompanied with a sufficient quantity of lime, silex, and alumine, or of oxide of manganese, it is not so injurious, because it becomes fusible, by combining with these substances.

Conceiving the advantage iron-masters would find, in having an easy method of knowing by simple inspection, a free from a refractory ore, Mr. Descotils has examined, whether among the external characteristics of these substances, there might not be some, by which these properties could be distinguished: but the strictest scrutiny, in this respect, was without success. He has been obliged, therefore, to have recourse to chemical means, and what he found most to the purpose, was fusing the ore without the addition of any flux.

If, after this operation, the matter present itself, in a grayish, earthy, friable mass, interspersed with small globules of cast iron, it is a proof, that the ore is magnesian, and consequently more or less refractory.

But, on the contrary, if a well fused button be obtained, with brown and not very abundant scoriæ, the ore is fusible, and contains but little magnesia.

When the scoriæ are green, they indicate the presence of oxide of manganese, part of which is reduced, and mixes with the cast iron, by a high and long continued heat.

The least altered kinds of sparry ores, that Mr. Descotils assayed, lost in roasting from 31 to 37 per cent. The altered or free ores lost at most, but 14 per cent. and this loss was merely water.

The quantities of magnesia and manganese vary greatly: sometimes there may be 12 per cent of either in the raw ore, and at others, there is scarcely any.

From the results of his analysis Mr. Descotils concludes, that a high proportion of one, excludes a high proportion of the other, without the absence of the one necessarily indicating the presence of the other: so that the iron, when brought to the state of red oxide, always amounts to 50 per cent. at least.

Hence Mr. Descotils explains what takes place in the Catalonian forges, where the different species of ores are treated, according to the nature, number, and quantity of the principles they contain. He points out the method that each requires, and the product they afford, according as the operation is conducted. Sometimes it is cast steel, at others malleable iron, or some mixture of the two. On this occasion, he expresses his surprise, that no one has yet thought of establishing a manufactory of cast-steel in the Pyrenees.

He thinks justly, that all rich iron ores, which contain but few earthy parts, such as those of the island of Elba, might be fused with advantage, in the Catalonian method.

It follows evidently, from the experiments of Mr. Descotils, that certain kinds of sparry ores, owe their infusibility to the presence of a large quantity of magnesia: and that the principal object of the exposure of these ores, to the air and rain, either before or after roasting, is to separate the magnesia, and render them fusible. The various experiments we have witnessed, and the results which we have seen, leave us no doubt on this head: since on the one hand, the ores in which there is no magnesia, are easy of fusion, and those which contain a certain proportion, are wholly infusible; while on the other, the addition of magnesia to fusible ores, divests them of this property, and infusible ores, when their magnesia is abstracted from them, become fusible.

From the observations of Mr. Descotils, it farther follows, that there is no external character, by which we can distinguish, whether a sparry iron ore, be fusible or not: but he has pointed out chemical means of determining their nature, which are easy in practice.

The following processes from Cramer and Gellert, are sufficient to direct the assay of iron ores, in the furnace.

Process I.

To reduce or precipitate iron, out of its ore, in a close vessel.

Roast for a few minutes in a test, under a muffle, and with a pretty strong fire, two centners of the small weight of your iron ore, grossly pulverised, that the volatile matters may be dissipated in part, and the ore itself be softened, in case it should be too hard. When it is grown cold, beat it extremely fine, and roast it a second time, as you do the copper ore, but in a much stronger fire, till it no longer emits any smell; then let it grow cold again. Compose a flux of three parts of the white flux, with one part of the fusible pulverised glass, or of the like sterile unsulphureous scoriæ, and add sandiver and coal-dust, of each one half part; add of this flux three times the quantity of your roasted ore, and mix the whole very well together; then choose a very good crucible, well rubbed with lute within, to stop the pores which may remain in different places unseen; put into it the ore mixed with the flux; cover it over with common salt, and shut it close with a tile, and with lute applied to the points.

Put the wind-furnace upon its bottom part, having a bed made of coal-dust. Introduce besides into the furnace, a small grate supported on its iron bars, and a stone upon it, whereon the crucible may stand, as on a support; surround the whole with hard coals, not very large, and kindle them at top: when the vessel begins to grow red, which is indicated by the common salt's ceasing to crackle, stop with gross lute, the holes of the bottom part of the furnace, except that in which the nozzle of the bellows is received; blow the fire, and excite it with great force, adding now and then fresh fuel, that the vessel may never be naked at top: having thus continued your fire in its full strength, for three quarters of an hour, or for a whole hour, in the next place, take the vessel out of it, and strike several times the pavement, upon which it is set, that the small grains of iron, which happen to be dispersed, may be collected into a but-

ton, which you will find after having broken the vessel.

When the button is weighed, try its malleability: then make it red-hot; and when it is so, strike it with a hammer: if it bear the strokes of a hammer, both when red-hot, and when cold, and extends a little, you may pronounce your iron very good; but if, when either hot or cold, it proves brittle, you may judge it to be not quite pure, but still partly mineralised.

Remarks. The arsenic, but especially the sulphur, must be dissipated by roasting; for the former renders the iron brittle, and the latter not only does the same, but being managed in a close vessel, with a saline flux, turns to an alkaline sulphuret; which acts strongly upon the iron, and prevents its reduction: so that the whole, or great part of it at least, is retained by the sulphureous scoria; in this case therefore, it is generally in vain to look for a metallic button.

The iron obtained from this first precipitation, has scarcely ever the requisite ductility, but is rather brittle, owing to the carbon it retains.

Process II.

The following process for assaying iron ores, and ferruginous stones and earths, is extracted from Gellert's Elements of Essaying.

Roast two quintals of iron ore, or of ferruginous earth: divide the roasted matter into two equal parts; to each of which add half a quintal of pulverised glass, if the substance be fusible, and contain much metal; but if otherwise, add also half a quintal of calcined borax. If the roasting have entirely disengaged, the sulphur and arsenic, an eighth part, or even half a quintal of quicklime may be added. With the above matters mix 12 pounds of charcoal powder.

Take a good crucible, and cover the bottom, and sides of its inner surface with a paste, made of three parts of charcoal dust, and one part of clay beaten together: in the hollow left in this paste, put the above mixture, press it lightly down, cover it with pulverised glass, and put on the lid of the crucible.

Place two such crucibles, at the distance of about four fingers from the air-pipe, in such a manner, that the air shall pass betwixt them, at about the third part of the height from the bottom; fill the space between the two crucibles, with coals of a moderate size; throw lighted coals upon them, that the fire may descend, and make them red-hot, from top to bottom; at first let the bellows blow softly, and afterwards strongly, during an hour, or an hour and a quarter; then take away the crucible, and break it when cold. A button will be found in the bottom, and sometimes some small grains of iron, in the scoria, which must be separated and weiged along with the button; then try the button, whether it can be extended under the hammer, when hot and when cold.

Remarks. To disengage a metal from the earthy matters, mixed with it by fire, we must change these matters, into scoria or glass. This change may be effected by adding some substance, capable of dissolving these matters; that is, of converting them into scoria or glass, from which the metallic matters may, by their weight, separate and form a button at bottom. Fixed alkali, which is an ingredient of the black, and of the white flux, is a powerful solvent, of earths and stones: but the alkali (by the assistance of sulphur) does also dissolve iron, especially when this metal is in an oxided state; and the solution is so much more complete, as the fire is longer applied. Hence, in ordinary assays, where an alkaline salt is used, little or no iron is obtained. Now, glass acts upon, and dissolves earths and stones; but not, or at least in a very small degree, iron; consequently glass is the best flux, for such assays; and experience confirms this assertion. If the ore contain but little iron, we may also add to the glass some borax; but borax cannot be employed singly, because it very soon fuses and separates, from the ore before the metal is revived. Quick-lime is added, not only to absorb the sulphur and arsenic remaining in the ore, but also because it dissolves and vitrifies, the stony and earthy matters of iron ores, which are generally argillaceous. For which reason, in the large operations for smelting iron ore, limestone, and even, in certain cases, gypsum, are commonly added, to facilitate the fusion.

The reduction of iron ore, and even the fusion of iron, require a violent and long-continued heat; and therefore in this operation, we must not employ an inflammable substance, as pitch, that is soon consumed; but charcoal pulverised, which in close vessels, is not sensibly wasted. Too much charcoal must not be added, else it will prevent the action of the glass, upon the earthy matter of the ore, and consequently the separation of the metallic part. Experiments convinced Cramer, that one part of charcoal dust, to eight parts of ore, was the best proportion.

When iron is surrounded by charcoal,

it is not decomposed or destroyed; hence the iron of the ore, which sinks into the hollow made of paste of charcoal dust and clay, remains there unhurt. The clay is added in this paste to render it more compact, and to keep the fluid iron collected together.

The air is directed between the crucibles, because, if it were thrown directly upon them, they would scarcely be able to resist the heat. The space between the air-pipe and the crucibles ought to be constantly filled with charcoal, to prevent the cold air from touching the crucibles. Ductile and malleable iron is seldom obtained in this first operation.

Mr. Mushet, in the assay of iron-stones, employs only bottle glass, chalk, and charcoal; varying their proportions, according to the nature of the stone. Supposing the earths to be in the proportion of, clay 9, lime 6, silex 3; to four parts of ore he puts glass 4, chalk 2, charcoal 0.5: when clay 10, silex 7, lime 3; glass 4, chalk 4, charcoal 0.75: when lime 14, clay 6, silex 4; glass 5, chalk 1.5, charcoal 0.75: when lime 10, silex 6, clay 4; glass 4, chalk 2, charcoal 0.5: when silex 12, clay 8, lime 5; glass 3, chalk 2, charcoal 0.75: when silex 10, lime 7, clay 5; glass 3, chalk 3.5, charcoal 0.75: and when neither of the earths predominates; glass 3.5, chalk 2.5, charcoal 0.5.

For other particulars respecting the properties of iron, and the treatment of its ores, see Iron.

Ores of Lead.

Lead has been found native in various parts of England, and elsewhere, or at least in the metallic state. But most mineralogists question the existence of native lead, and consider the specimens produced as such, to be either the produce of ancient founderies, or purer kinds of lead ore. Hence we may conclude, that the unequivocal specimens of native lead are scarce; but the curious specimen mentioned by Bomare, in the second volume of his Mineralogy, quoted by Magellan, appears to be decisive in favour of the existence of this metal in a native state. It was in the collection of the Abbé Nollin at Paris, and came from the lead mines of Pompean, near Rennes, in Brittany. This metal was very malleable, could be cut with a knife without crumbling, and easily melted over the flame of a candle. It weighed about two pounds; was imbedded in an earthy lead ore of a reddish colour, and had a slaty vein, that went through it.

Lead is found mineralized by the sulphuric acid. According to Mr. Monnet, who calls this the pyritous ore of lead, it sometimes occurs in the form of a white ponderous oxide, soluble in 16 or 18 times its weight of water. It does not effervesce nor is it soluble in other acids; it may be reduced by laying it on a burning coal. It originates from the spontaneous decomposition of sulphuretted lead ores. Mon. Mineral. 371. According to Dr. Withering, it is found in great quantity in the island of Anglesea, but united to iron, and not reducible by the blowpipe or charcoal; it contains 70 per cent. of lead. This is of a yellow colour, and mixed with clay.

The green lead ore, discovered by Gahn, consists of lead mineralized by the phosphoric acid. If urged by the blowpipe, it melts, and affords an opake globule without reduction, which in cooling assumes a polyhedral form, the facets of which, though apparently plain, are, in fact, composed of concentric striæ, when observed by the microscope.

The red-lead spar or ore consists of lead mineralized by chromic acid, and has not hitherto been found elsewhere than at Catherineburgh, in Siberia. Externally it is of a pale, and internally of a deep red colour, and for the most part crystallized in rhomboidal parallelopipeds, or irregular pyramids. According to Vauquelin, it contains nearly 65.12 of oxide of lead, and 34.88 of chromic acid. Mongez mentions a lead ore of a greenish yellow colour, in a matrix of quartz, coming from Siberia, which Vauquelin found to be a chromat likewise. Lehman and Mongez had both supposed the lead in these chromats to be mineralized by arsenic.

The yellow lead ore of Carinthia was found by Klaproth to be a molybdat. By Mr. Hatchett's analysis, 100 parts give lead 58.4, molybdic acid 38, oxide of iron 2, with a small proportion of silex. Spec. grav. 5.092.

A beautiful yellow lead, in silky filaments, very slightly flexible, was lately discovered in France by Mr. Champeaux, which is a combination of lead with arsenic acid or oxide.

The calciform lead ores contain carbonic acid, which is considered as the mineralizer. They effervese with acids, and are easily reduced on the charcoal. Kirwan distinguishes five varieties.

1. White lead spar, lead ochre, or native ceruss. It is sometimes transparent, but generally opake, and crystallized in regular forms, of a laminar or striated texture. Lead ochre, or native ceruss, is the same substance, but in a loose form or indurated and shapeless; sometimes it is found in a silky form. Both contain a little

iron, and sometimes calcareous earth and argill. Both grow red hot or yellowish when sufficiently heated. They effervesce with acids, and afford from 60 to 80 or 90 per cent. of lead. Both are found in Baittany, Lorraine, Germany and England.

2. Red, brown, or yellow. This is also found either regularly crystallized, or in shapeless masses, or in powder. It differs from the former only by containing more iron. That in powder contains a mixture of clay. It affords about 70 or 80 per cent. of lead.

3. Green. Either crystallized in needles as in Brittany, or in loose powder as in Saxony, but mostly adhering to or investing quartz. It owes its colour to iron, and seldom contains copper.

4. Blueish. This is also sometimes crystallized, sometimes irregular.

5. Black. The most uncommon of all, and occurs either crystallized, or of an indeterminate form.

Lead mineralized by sulphur is the commonest of all lead ores. It is known by the name of galena, or potters' lead ore, and is of a blueish dark lead colour, formed of cubes of a moderate size, or in grains of a cubic figure, the corners of which have been cut off; its texture is lamellar, and its hardness variable: the hardest sort containing a greater mixture of iron or quartz; that in grains is thought to be the richest in silver; but the richest contains only about one or 1.5 per cent.; that is, 12 or 18 ounces per quintal: the poorest about 60 grains. Ores that yield about half an ounce of silver per quintal, are barely worth the cost of extracting them: the proportion of sulphur to lead in this ore is also variable within the limits of 15 and 25 per cent.; that which contains least is called bley schweif, and is in some degree malleable. The proportion of lead is from 83 to 45 per cent. by reason of an accidental mixture of quartz, that of iron is generally very small. Dr. Watson remarks, that the ores which are poorest in lead, are often the richest in silver. The specific gravity of galena is from 6 565 to 7.786; when melted, it yields a yellow slag.

The antimonial lead ore has the same colour and weight as galena, but its structure is commonly radiated like that of the ore of antimony. Beside the more accurate methods of humid solution, the antimony may be easily perceived, though in small quantities, by the white and abundant fumes it emits in roasting.

In the smelting of ores of lead they may be considered either as pure, that is, containing no mixture of other metals, or they are mixed with silver, copper, or pyrites.

Pure ores of lead, and those which contain so small a quantity only of silver as not to compensate for the expense of extracting the nobler metal, may be smelted in furnaces, and by operations similar to those used at Rammelsburg, or by the following methods.

1. From the lead-ore of Willach in Carinthia a great part of the lead is obtained by a kind of eliquation, during the roasting of the ore. For this purpose, the ore is thrown upon several strata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a basin placed for its reception. The ore which is thus roasted is beaten into smaller pieces, and exposed to a second operation similar to the former, by which more metal is eliquated; and the remaining ore is afterward ground, washed, and smelted in the ordinary method.

The lead of Willach is the purest of any known. Schlutter ascribes its great purity to the method used in extracting it, by which the most fusible, and consequently the purest part of the contained lead, is separated from any less fusible metal, which happens to be mixed with it, and which remains in the roasted ore. This method requires a very large quantity of wood.

2. In England lead ores are smelted either upon a hearth, or in a reverberatory furnace, called a cupel.

In the first of these methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fusion is very speedily effected; and the lead flows from the hearth as fast as it is separated from the ore.

3. In the second method practised in England pit-coal is used as fuel. The ore is melted by means of the flame passing over its surface; its sulphur is burnt and dissipated, while the metal is separated from the scoria, and collected at the bottom of the furnace. When the ore is well cleansed and pure, no addition is requisite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fusible spar found in the mines is generally added, to render the scoria more fluid, and thereby to assist the preparation of the metal. When the fusion has continued about eight hours, a passage in the side of the furnace is opened, through which the liquid lead flows into an iron cistern

But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid mass a quantity of slaked quick-lime, which renders the scoria so thick and tenacious, that it may be drawn out of the furnace by rakes.

Schlutter mentions this addition of quick-lime in the smelting of lead-ores in England, but thinks that it is intended to facilitate the fusion of the ores; whereas it really has a contrary effect, and is never added till near the end of the operation, when the scoria is to be raked from the surface of the metal.

Ores of Manganese.

From the extreme disposition of manganese to become oxided, it is hardly to be expected that the metal should be found native. But Mr. Peyrouse describes a substance of this kind in the Journal de Physique for 1786, which appears to be native manganese from the following properties.

1. Its external appearance, colour and figure are the very same as those of the metallic manganese reduced by art.

2. It likewise soils the fingers when handled.

3. Its substance is quite pure, having no particles that are in the least attracted by the magnet.

4. Its texture is lamellated, and the lamellæ seem to affect a kind of divergence among themselves.

5. It has the very same metallic brilliancy as the artificial manganese.

6. It has also a partial malleability; and, when repeatedly hammered,

7. It exhibits a kind of exfoliation, forming itself into very thin leaves.

8. Its opacity and density are so completely similar to that of the artificial regulus, that, were it not for the natural matrix in which it is imbedded, it could not be at all distinguished from it.

9. This ore is not found in large masses, or in a solid continued body, but only in lumps, and unconnected clots, enclosed and intermixed with the powdery manganese ore.

10 These lumps are somewhat flattened, or compressed in their figure, like the artificial ones, though they are, for the most part, of a larger size.

11. And this powdery manganesian ore, in which the reguline lumps are imbedded, has an argentine hue, which seems to countenance the suspicion of its having been acted upon by the violent heat of some natural deflagration on the spot.

It was found among the iron mines of Sem, in the valley of Vicdessos, in the county of Foix, near the Pyrenean mountains.

The only ores of manganese yet well known are its oxides, which vary greatly in colour, texture, and other properties, both from their degree of oxidation, and from foreign admixtures. They are likewise crystallized, amorphous, or of various shapes; and vary in specific gravity from 3.233 to 4.81. One of these ores, the garnet-shaped, is of a deep hyacinthine red; when undecayed, very resplendent, of a fine diamond lustre; and strongly transparent on the edges. It consists of oxide of manganese 35, oxide of iron 14, silex 35, alumine 14.25.

A carbonat of manganese is found in the mines of Nagyag in Transylvania, and it is said also in France, and in Norway. It is in masses of a pale rose colour, which, as it is acted upon by the air, turns to a light yellowish brown. It is void of lustre, hard and brittle. Lampadius found its component parts to be

Oxide of manganese	48
Carbonic acid -	49.2
Oxide of iron - -	2.1
Silex - -	0.9
	100.2

To analyse these ores, they should be first roasted to oxide effectually the manganese, and iron, if any; then treated with dilute nitric acid, to dissolve the earths; the residuum should then be treated with muriatic acid, assisted by gentle heat; and the solution precipitated by carbonat of soda.

The precipitate will be oxide of manganese, and of iron, if the latter were present, which will be known by boiling it in a concentrated solution of potash, as this will dissolve the manganese only. If the ore contained barytes, this will be precipitated from the nitric solution by sulphuric acid: if lime, it may be precipitated by carbonat of potash.

Ores of Mercury.

Mercury is found in a native state sufficiently distinguishable from every other metallic substance, by its fluidity in every ordinary temperature of the habitable parts of the globe. Bergman doubts whether it be ever found uncontaminated by any other metal. It is found in the quicksilver mines in small brilliant globules, disseminated in different gangues. Mongez asserts, that it is mostly in a state of great purity. Sometimes it is collected in the cavities of rocks, as at Idria in Friuli, Almaden in Spain, and in Ameri-

ca: and in other instances it is disseminated in the earth, in clays, or adherent to quartzose stones, pot-stone mica, or else mixed with different ores, as the white or red silver ores, galena, white arsenic, or cinnabar.

Mercury has been found in Sweden and elsewhere united to silver in the form of an amalgam, sometimes crystallized.

Mr. Sage, in the Journal de Physique for 1784, mentions a native oxide of mercury of a red-brown colour, difficult of fracture, presenting a granulated texture more red than externally. It frequently contains running mercury in its interstices. By distillation, it yields of mercury from 20 to 80 per cent. It contains a small part of silver, and comes from Idria.

Mercury was found by Mr. Woulfe at Obermoschel in the duchy of Zweybrueecken, united with the muriatic and sulphuric acids. These ores have a spar-like appearance, and are either bright and white, or yellow or black mixed with cinnabar in a stony matrix. The muriatic was in the state of corrosive sublimate.

The ore of mercury which is wrought in the large way is CINNABAR. It is a combination of mercury, with one fourth of its weight of sulphur. See CINNABAR.

There are other impure cinnabars, particularly one containing copper, which is of a blackish gray colour, glassy texture, and decrepitates strongly when heated. The cinnabar may be volatilized by heat, and the remaining copper shews itself by the usual tests. The ore of mercury containing iron, and distinguished by the name of pyritous mercurial ore, is a gray or whitish friable substance found in Dauphiny, and afforded Mr. Monnet one part of mercury, less than half a part of silver, and the rest was iron, cobalt, arsenic, and silver.

PROCESS I.

To separate Mercury out of an unsulphureous ore by distillation.

Take a lump of the pulverized ore, one common pound, which must stand for one centner; put it into a glass retort perfectly clean, well loricated, or coated up to half the length of its neck: this must be very long, and turned backwards with such a declivity, that a glass recipient may be perpendicularly applied to it: but you must choose a retort small enough, that the belly of it may be filled hardly two-thirds with the ore: this retort must be placed so, that nothing of the fluid adherent to the neck of it, may fall into the cavity of the belly, but that the whole may run forward into the recipient. Lastly, take a small recipient full of cold water; let it be placed perpendicularly, and receive the neck of the retort in such a manner, that the extremity of it may be hardly one half inch immersed in the water.

Let the retort be surrounded with hot burning coals placed at some distance in the form of a circle, lest the vessel should burst by too sudden a heat: then by degrees bring the burning coals nearer and nearer, and at last surround the whole retort with them and with fresh charcoal, that it may grow slightly red-hot: this fire having been continued for an hour, let the retort cool of itself: then strike the neck of it gently, that the large drops which are always adherent to it may fall into the recipient: let the recipient be taken away, and the water separated from the mercury by filtration, and let the mercury be weighed. This operation may be more conveniently performed in a sand bath; in which case the pot containing the sand must be red-hot, and the retort be able to touch the bottom of it immediately; nor is it then necessary that the retort be loricated.

PROCESS II.

To revive mercury from a sulphureous or cinnabar ore.

Beat your ore extremely fine, and mix it exactly with an equal proportion of iron filings, not rusty; and proceed to distil it with the same apparatus as in the former process; but urge it with the strongest fire that can be made.

Cinnabar may be separated from stones by sublimation as follows. Beat it to a fine powder, and put it into a small narrow glass or earthen cucurbit, of the belly of which it must not fill more than one third part: stop the orifice at top; this must be very narrow, to hinder the free action of the air. Put this small cucurbit into an earthen pot above two inches in diameter, and gather sand around this pot about as high as the pulverized ore rises in the cucurbit. Then put it upon burning coals in such a manner, that the bottom of the pot may be moderately red-hot. Thus will your cinnabar ascend, and form a solid ponderous ring, which must be taken out by breaking the vessel.

Ores of Molybdena, are not used in the arts.

Ores of Nickel.

This semimetal has been found by Rinman in a cobalt-mine in Hesse. The mineral is very ponderous, and of a livid colour. When pulverized and roasted under a muffle, it forms a green excrescence, and smokes; but its smoke has no pecu-

liar smell, and no sublimate, whether sulphureous or arsenical, can be caught. It affords a green solution with acids; but a polished iron plate discovers no indication of copper.

Nickel is also found in the state of oxide, afforded by the decomposition of kupfer nickel. It usually has the form of a green efflorescence, and often covers the ores which contain it. Cronstedt informs us, that it is found at Normark in Warmeland, without any appearance of kupfer nickel, in a clay which contained much native silver.

The ore long distinguished by the name of kupfer nickel, before the discovery of the peculiar metal by Cronstedt, is of a reddish-yellow colour, and of the texture and appearance of a slag, or else of a fine granular texture; or lastly, of a scaly or lamellar texture. Its brilliancy in some measure resembles that of the common pyrites. This ore contains nickel, with iron, cobalt, and arsenic, mineralized with sulphur. See NICKEL.

Ores of Osmium.

This metal has been found hitherto only in small quantity among the black powder left after dissolving platina.

Ores of Palladium.

This too has been found only with Platina.

Ores of Platina.

This comes to us in an impure native state. Its ores, if any, are unknown.

Ores of Rhodium.

Rhodium has yet occurred only in the grains of crude platina.

Ores of Silver.

The great value of this metal has occasioned its ores to be very particularly attended to, and enumerated.

Native silver is found in a granular, lamellar, filamentous, capillary, arborescent, or crystallized form, inhering either in sulphat of barytes, lime-stone, sulphat of lime, quartz, chert, flint, serpentine, gneiss, agate, mica, calcareous spar, pyrites, schistus, clay, &c.; also in separate masses of various sizes, some of the weight of 60 pounds, in or near the veins of most metallic substances, particularly in Peru, and frequently in various parts of Europe, either of a white, brown, or yellowish colour.

It is often diffused through sand and ochre, also in gray lime stone in Lower Austria, and in a greenish clay near Schemnitz, or mixed with ochre, clay, and oxide of nickel.

It is seldom found pure, being generally alloyed with copper, and sometimes with a small proportion of gold, iron, or antimony, and sometimes about five per cent. of arsenic; it is separable from gold and antimony by solution in nitric acid; from copper and iron by precipitating it by the muriatic acid; and from arsenic by torrefaction. Cronstedt says its purity is generally approaching to 16 carats. Lewis asserts, that it never exceeds this fineness. The native silver found near Konigsberg contains so much gold, as to acquire a yellow colour from it.

Horn-silver, or corneous silver ore, is of a whitish-gray, or dirty yellow, sometimes semitransparent, easily cut with a knife, fusible even by the flame of a candle, and assuming a violet colour by the sun's rays. One hundred grains contain from 28 to 74 of real siver. In some ores the muriat is mixed with 67 per cent. of argil. It is reducible by triturating it with about its own weight of fixed alkali with a little water, then melting the whole in a crucible, the bottom of which is covered with soda well pressed, and covering the mass of horn-silver also with the soda.

The vitreous silver ore (silberglasertz) is mineralized by sulphur. It is found either in solid large lumps, or inhering in quartz, spar, gypsum, gneiss, pyrites, &c.; of a lamellar, granular, or capillary form crystallized. It is generally of a lead colour first, but grows black by exposure to the air, but sometimes gray or black, even when first broken; its laminæ are flexible and ductile, and even malleable in some degree, and so soft, that they may be cut with a knife; its specific gravity is 7.200. It is one of the richest of the silver ores, containing about .85 of metal.

The black silver ore, schwartzguldenertz, silbermulm, is considered as a variety of this.

The brittle vitreous silver ore, analysed by Klaproth, gave, in 100 parts, silver 66.5, antimony 10, iron 5, sulphur 12, copper and arsenic about 0.5, extraneous matter from the mine 1.

It is analysed by boiling in moderately dilute nitric acid, using about 25 times its weight, till the sulphur is quite exhausted. The silver is precipitated by muriatic acid, or common salt. The Prussian alkali will show if any other metal is contained in the solution: the gold, if any, will remain undissolved; fixed alkalies will precipitate any other earthy matters contained in the solution.

In the dry way it may be reduced by melting it with the blow-pipe on char-

coal; for the sulphur is dissipated, and the silver remains; or by melting it with one eighth of its weight of filings of iron, as the iron will take up the sulphur, and be scorified.

Silver is either mineralized by a small or a large proportion of arsenic. The ore which is mineralized by a small proportion of arsenic is of a yellowish-white colour, and of a striated texture, resembling bismuth, but much harder; it melts very easily; and if kept in fusion, it loses its arsenic, and the silver remains almost entirely pure, as it contains but very little iron; it contains about 90 per cent. of silver, and is found near Quadanal canal in Spain.

The proportion of arsenic in that silver ore, which is mineralized by a large proportion of it, is so great, that it would scarce deserve to be called a silver ore, if the arsenic were not easily dissipated: the quintal contains but from four to six ounces of silver: it is very soft, and easily cut, and when cut has a brilliant metallic appearance; it consists of conchoidal laminæ; it is also found at Quadanal canal. It is reduced by evaporating the arsenic, which then leaves the silver slightly contaminated with iron.

A silver ore of this kind analysed by Klaproth, gave silver 12.75, iron 44.25, arsenic 35, antimony 4.

The red silver ore (rothguldenertz) is a heavy, shining substance, either transparent or opake, mostly of a crimson or reddish colour, though sometimes gray or blackish, but when scraped or powdered always reddish; found either in irregular masses, or crystallized in pyramids or polygons, or dendritical, or plated, or radiated incrustations, on or in matrixes of quartz, flint, spar, pyrites, sparry iron ore, lead ore, pyrites, cobalt ore, jasper, gneiss, &c. When radiated or striated, it is called rothgulden bluth. In the fire it crackles and melts after it has acquired a red heat, with an arsenical smell; it detonates with nitre: its specific gravity is from 5.4 to 5.684. Bergman found 100 grains of it to contain 60 of silver, 27 of arsenic, and 13 of sulphur; but sometimes it contains even 70 per cent. of silver. The darkest ores are the richest, and these often contain a little iron; the yellowest are the poorest; the most yellow does not belong to this species, being in fact orpiment, containing six or seven per cent. of silver.

To analyse this ore in the moist way, Bergman advises to boil it after it is reduced to a very fine powder in dilute nitric acid, and to edulcorate the residuum very carefully which contains the sulphur and arsenic, which may be separated by boiling in a sufficient quantity of aqua regia: if the sulphur still retain any muriat of silver, it may be separated by pure ammonia.

In the dry way, it is reduced after torrefaction by a mixture of iron and lead; the iron takes up the sulphur, and the lead the silver, which is afterward separated by cupellation.

Klaproth, however, denies that it contains arsenic, as not the least vestige of it was to be found in a bright red crystalline ore from the Hartz, or another from Freiberg. The former gave silver 60, antimony 20.3, sulphur 11.7, concrete sulphuric acid 8; the latter, silver 62, antimony 18.5, sulphur 11, concrete sulphuric acid 8.5. The sulphur and its acid he supposes to have been united in the state of an oxide of sulphur in the ore.

Another species of silver ore mineralized by sulphur, and containing a large proportion of lead, is called white silver ore, weissgultigertz. Analysed by Klaproth, 100 parts gave silver 20.4, lead 48.06, antimony 7.88, iron 2.25, sulphur 12.25, alumine 7, silex 0.25. A variety of this dark white silver ore, gave silver 9.25, lead 41, antimony 21.5, iron 1.75, sulphur 22, alumine 1, silex 0.75. Klaproth distinguishes this from the weissguldenertz of Kremnitz, which has been confounded with it, and which he calls gray silver ore, as it resembles the gray copper ore more than it does the white silver. This gave him silver 14.97, copper 31.36, antimony 34.09, iron 3.3, sulphur 11.5, alumine 0.3. What has frequently been called gray silver ore, fahlertz, is properly an ore of copper, containing accidentally a small portion of silver only.

A bismuthic silver ore was found by Selb, about fifteen years ago, at Schapbach, in the Black Forest. It is chiefly disseminated in quartz; and, analysed by Klaproth, 100 parts gave lead 33, bismuth 27, silver 15, iron 4.3, copper 0.9, sulphur 16.3.

In the duchy of Zweybruecken, a native amalgam of silver occurs in various forms. Some pure garnet-like crystals of it, analysed by Klaproth, gave mercury 64, silver 36.

And in Suabia, an alloy of silver and antimony occurs, one variety of which, in fine grains, contains .84 of silver: another, in coarse grains, .76: the remainder in each being antimony.

The following processes, like the others extracted from Cramer's Art of Assaying,

are valuable for the minute accuracy of the instruction as to the management of assays by the furnace.

PROCESS I.

To precipitate silver by means of lead from fusible ores.

Pound the ore in a very clean iron mortar into fine powder: of this weigh one docimastical centner or quintal, and eight of the like centners of granulated lead.

Then have at hand, a docimastical test, that has never yet been used: pour into it about half of the granulated lead, and spread it with your fingers through the cavity of it.

Put upon this lead the pounded ore; and then cover it quite with the remainder of the granulated lead.

Put the test, thus loaded, under the muffle of an assay-furnace, and in the hinder part of it: then make your fire, and increase it gradually. If you look through the holes of either of the slides, you will soon see, that the pounded ore will be raised out of the melted lead, and swim upon it. A little afterward, it will grow clammy, melt, and be thrown towards the border of the test: then the surface of the lead will appear in the middle of the test like a bright disk, and you will see it smoke and boil: as soon as you see this, it will be proper to diminish the fire a small matter for a quarter of an hour, so that the boiling of the lead may almost cease. Then again increase the fire to such a degree, that the whole mass may be converted into a thin fluid, and the lead may be seen, as before, smoking and boiling with great violence. The surface will then diminish by degrees, and become covered with a mass of scoriæ. Finally, have at hand an iron hook ready heated, wherewith the whole mass must be stirred, especially toward the border; that in case any small parcels of the ore, not yet dissolved, should be adherent there, they may be brought down, taking great care not to stir the least particle out of the test.

Now, if what is adherent to the hook during the stirring, when you raise it above the test, melt quickly again, and the extremity of the hook, grown cold, be covered with a thin, smooth, shining crust; it is a sign that the scorification is perfect; and it will be the more so, as the said crust adherent to the hook shall be coloured equally on every side; but in case, while the scoriæ are stirred, you perceive any considerable clamminess in them, and when they adhere in good quantity to the hook, though red-hot, and are unequally tinged, and seem dusty or rough with grains interspersed here and there; it is a sign that the ore is not entirely vitrefied. In this case, you must with a hammer strike off what is adherent to the hook, pulverize it, and with a ladle put it again into the test, without any loss, or mixture of any foreign body, and continue the fire in the same degree, till the scoria has acquired its perfection, and the above-mentioned qualities. This once obtained, take the test with a pair of tongs out of the fire, and pour the lead, together with the scoria swimming upon it, into a cone made hot and rubbed with tallow Thus will the process of the first operation be performed, which does not commonly, indeed, last above three quarters of an hour.

With a hammer strike the scoriæ off from the regulus grown cold, and again examine whether they have the characteristics of a perfect scorification: if they have, you may thence conclude that the silver has been precipitated out of the ore turned to scoriæ, and rceived by the lead.

When the scorification lasts longer than we have mentioned, the lead at last turns to scoriæ or litharge, and the silver remains at the bottom of the vessel; but the fire must be moderately supplied, and the vessel be extremely good, to produce this effect; for they seldom resist the strength of the scoriæ long enough; so that the whole scorification may be brought to an end; which has afterward this inconvenience, that the silver is dissipated by grains in the small hollows of the corroded ore, and can hardly be well collected again, when the ore has but little silver in it. Indeed, there is still more time to be consumed to obtain the perfect destruction of the lead, by means of the combined actions of the fire and air, because the scoriæ swimming at the top retard it considerably.

In this process, the sulphur and the arsenic of the silver ore, when the ore is broken small, and extended widely in a small quantity, are in part easily dissipated by the fire, and in part absorbed by the lead; the lighter part of which, swimming upon the heavier, becomes very clammy, by means of the sulphur which is in the ore: but when this is dissipated, by the violence of the fire, it turns into glass or scoriæ: but when arsenic is predominant in the ore, the plumbeous part turns immediately, into a very penetrating and very fusible glass, having a dissolving efficacy, unless the arsenic lies hidden, in a white pyrite or cobalt. For this reason, the fixed part of the ore, which is no silver, is

dissolved by the glass, melts, and assumes the form of scoriæ. The unmetallic earths and the pure copper of lead-ores, which adheres to it, are of this kind. The silver then remains immutable; and being freed from these heterogeneous bodies, which are partly dissipated, and partly melted, it is precipitated and received by the remaining lead. Hence this process is completed by three distinct operations; viz.

1. By roasting.
2. By scorification.
3. By the melting precipitation of the silver, which is the result of the two former operations.

The ore must be pulverised very fine, in order to increase the surface, that the dissipation of the volatiles, and the dissolution by litharge, may be sooner effected. This pulverizing must be done, before the ore is weighed, because there is always some part of the ore, adherent to the mortar or iron plate, on which it is made fine; which part being lost, the operation is not exact. Erker was in the right, when he prescribed eight centners of lead, for the subduing of fusible ores.

Nevertheless it must be owned, that this quantity is superfluous, in some cases. However, as the fluxibility of the silver ore, depends on the absence of stones, pyrites, &c., it is easy to see, that there are an infinite number, of degrees of fluxibility, which it would be needless to determine by the bare sight. Besides, a little more lead does not render the process imperfect; on the contrary, if you use too small a quantity of lead, the scorification is never completely accomplished. Indeed there are a great many ores, that destroy a considerable quantity of lead: such are the red silver ore, and that in which there is a great deal of the steel-grained lead ore. If the fire must be sometimes diminished, in the middle of the process, it is in order to hinder the too much attenuated litharge, which is continually generated out of the lead, from penetrating the pores of the test, and from corroding it; which is easily done, when the fire is over strong; for then the surface of the vessel, which is contiguous to the lead, contracts cavities, or being totally consumed by small holes, lets the metal flow out of it. The vessels that are most subject to this inconvenience are those, in the materials of which lime, plaster, and chalk, are mixed. Nay, these bodies, which are naturally refractory, being eroded during their scorification, at the same time communicate a great clamminess to the scoria; so that a great quantity of the mass, remains adherent to the test, in the form of protuberances, when it is poured out; and by this means a great many grains of the regulus are detained.

Process II.

The button obtained by the preceding process, contains all the silver of the ore, and the unscorified part of the lead. The silver may be afterwards separated from the lead, and obtained pure, by cupellation.

Process III.

If the silver ore cannot be washed clean, or if it be rendered refractory by a mixture of unmetallic earths and stones, the scorification of these earthy matters, frequently cannot be completed by Process I: Cramer *therefore directs, that such ores, shall be treated in the following manner.*

Bruise the ore into an impalpable powder, by grinding in a mortar; to a docimastical centner of it, add a like quantity of glass of lead, finely pulverized: for the more exactly, these two are mixed together, the more easily the scorification afterward succeeds. Put this mixture, together with 12 centners of lead, into the test, according to Process I; then put the test under the muffle.

Make first under it a strong fire, till the lead boils very well; when this takes place, diminish the violence of the heat, as was directed in Process I, but keep it thus diminished a little longer: then finally again increase the fire to such a degree, till you perceive the signs of a perfect scorification, and fusion. Now this process, lasts a little longer than the foregoing, and requires a greater fire toward the end.

It sometimes happens, that a very refractory ore cannot be dissolved by litharge, and that a mass, which has the clamminess of pitch, swims upon the metal, and upon the scoriæ themselves, which are already subdued in part: when this takes place, shut the vents of the furnace to diminish the fire; then gently touch this refractory body, with a small iron hook, to which it will immediately stick; take it off softly, not to lose any thing; pound it into a fine powder, adding a little glass of lead, and put it again into the test; then continue the scorification, till it is brought to its perfection. But you must always examine the scoria of your refractory ore, to see whether there may not be some grains of metal dispersed in it: for sometimes, the scoriæ that grow clammy retain something of the metal;

which if you suspect, pound the scoria into a fine dust, and thus the grains of metal will appear, if there be any left, because they can never be pounded fine. The silver is separated by cupelling, as in Process I.

All earths and stones are refractory in the fire; for although some of them melt naturally in the fire, as is the case with those that are vitrifiable; yet all the others, a very few excepted, melt with much greater difficulty than metals, and never become so thin in the fusion as is requisite for the sufficient precipitation of a precious metal. But litharge does not conveniently dissolve these refractory matters, by the help of fire alone, without mechanical mixture; for the very moment the litharge penetrates, through the interstices of the refractory ore, and begins to dissolve it, a tenacious mass is produced, which hardly admits any farther dilution, by the litharge. You may plainly perceive this, when you make coloured glasses, with metallic oxides; for, if you pour carelessly upon them, an oxide that gives a colour, you will never cause them, to be equally tinged throughout, even though you should torture them, for whole days together, in a strong fire. Indeed, glass already made can never be diluted, by only pouring salts and litharge upon it. Hence, you must use the artifice of glass-makers, who, in the making of the most perfect glasses, take great care to mix their ingredients well, either before they put them into the fire, or at least during the fusion itself, which is done here by pounding glass of lead, mixed with the ore: but if you think, that your glass of lead is not sufficiently fusible, you may add to it litharge, melted first, and then pounded into a fine powder.

As this scorification requires a longer and a greater fire than the foregoing, and as a greater quantity of litharge, is beside this requisite to subdue the refractory scoria; it is easy to see, why a much greater quantity of lead must be used here, than in Process I; and although less lead is often sufficient, it is nevertheless proper, always to use the greatest quantity that can be requisite; lest, for instance, it should be necessary to try so many times, the lead alone, to make it evident how much silver the lead, when alone, leaves in the cupel. Nor is there any occasion to fear, lest any thing of the silver, be taken away by the lead, provided the cupels be good, and the cupelling duly put in execution: for you can hardly collect a ponderable quantity of silver, out of the fumes of the lead, which rise during the cupelling, as well as out of the litharge, that is withdrawn into the cupel.

Process IV.

If the ore be rendered refractory by pyrites, Cramer *directs, that the silver should be precipitated by lead, in the following manner.*

Break your ore into a rough powder, and put a centner of it into the test in the manner of a tile; put it under the muffle hardly red-hot: increase the fire by degrees. There will always be a crackling; which being ended, take away the upper test; for when the vessels have been red-hot about one minute, the ore ceases to split. Leave the ore under the muffle, till the arsenic and the sulphur, are for the most part evaporated; which you will know from the cessation of the visible smoke, of the smell of garlic, or the acid; then take away the test, and leave it in a place not too cold, that it may cool of itself.

Pour out, without any dissipation, the roasted ore, and with a knife take away what is adherent to the vessel; pound it together with an equal weight of glass of lead; and lastly, scorify the whole collected ore, in the same test, in which the testing was made, unless it had contracted chinks, as was described in Process III.

Remarks. Yellow pyritous ores contain a very great quantity of sulphur, even greater than is necessary to saturate the metal that lies concealed in them. For which reason, this superfluous sulphur dissipates in a middling fire: but if it had been mixed with lead, it would have rendered it refractory, nor could it afterward be dissipated from it, without a considerable destruction of the lead. The white arsenical pyrites, turn also a great quantity of lead into glass, on account of the abundance of the arsenic they contain. In consequence of this, these ores must be previously roasted, that the sulphur and arsenic may be dissipated Nor is there any occasion to fear, lest any part of the silver, be carried away with the arsenic; for when arsenic is separated from any fixed body, by a certain degree of fire, it carries nothing of that body away with it.

Process V.

Silver may be precipitated from its ore by cupellation only, in the following process, given by Cramer.

Pound one centner of ore roasted in the manner directed in the last process; beat it to a very subtile powder; and if it melt with difficulty on the fire, grind it toge-

ther with one centner of litharge, which is not necessary, when the ore melts easily; then divide the mixture, or the powder of the ore alone, into five or six parts, and wrap up every one of them severally in such bits of paper, as can contain no more than this small portion.

Put a very large cupel under the muffle; roast it well first, and then put into it 16 centners of lead; when the lead begins to smoke and boil, put upon it one of these portions, with the small paper it was wrapped up in, and diminish the fire immediately, in the same manner, as if you would make a scorification in a test, but in a less time. The small paper, which turns presently to ashes, goes off of itself, and does not sensibly increase the mass of the scorias. The ore proceeding from this is cast on the border, and very soon turns to scoriæ. Increase the fire again immediately, and at the same time put another portion of the ore into the cupel. The same effects will then be produced. Continue your operations in the same manner, till all the portions are thrown in and consumed in the lead. Lastly, destroy the remaining lead with a stronger fire.

The silver that was in the ore, and in the lead will remain in the cupel. If you deduct from it the bead, proceeding from the lead, you will have the weight of the silver contained in the ore. If the ore employed were easy to be melted, all the scoria vanishes; but if it were refractory, or not fusible, all the scoria does not always pass away, but there remains something of it occasionally, in the form of dust. A great many ores and metals may be tried this way, except such only as split and corrode the cupels. There are likewise some of them, which must be previously prepared, in the same manner as is required to render them fit for going through a scorification. See the preceding Processes.

Remarks. The ore thrown at several times upon lead boiling in a cupel, may be dissolved without the foregoing scorification: but this is very far from having an equal success with all kinds of ores; for there are ores and metals, which resist very much the dissolution by litharge; and which being on this account thrown on the border, are not sufficiently dissolved; because the litharge soon steals away into the cupel. Nevertheless there are some others, which vanish entirely by this method, except the silver and gold, that were contained in them. A previous roasting is necessary; first, for the reasons mentioned, and then, because the ore thrown upon boiling lead, should not crackle and leap out; for, having once passed the fire, it bears the most sudden heat.

Process VI.

Silver may be precipitated out of the same bodies as were mentioned in the foregoing processes, by scorification in a crucible.

The body out of which you intend to precipitate silver, must be previously prepared for a scorification, by pounding and roasting, as mentioned in the former processes. Then in the same manner, and with the same quantity of lead, put it into a crucible, which is found on strict examination to be entire, solid, not speckled with black spots, like the scoria of iron, especially at its inferior parts, and capable of containing three times as much. Add besides glass-gall and common salt, both very dry, and in sufficient quantities, that, when the whole is melted, the salts may swim at the top, at the height of about half an inch.

Put the crucible thus loaded into a wind-furnace; shut it close with a tile; put coals round it, but not higher than the upper boarder of the crucible. Then light them with burning coals, and increase the fire till the whole melts very thin, which will be done by a middling fire, maintained always equal, and never greater; leave it thus for about one quarter of an hour, that the scorification may be perfectly made. Take off the tile, and stir the mass with an iron wire, and a little after pour it out into the mould. When the metal is cleared from scoriæ, try it in a test by cupelling it.

Remarks. The scorification of any ore whatever, or of any body fetched out of ores, may indeed be made by this apparatus, as well as in a test under a muffle: but it serves chiefly to the end, that a greater quantity of metal, may be melted from it with profit. For you may put many common pounds of it, at one single time into the crucible; but then you need not observe the proportion of lead in the foregoing process; indeed, a quantity of lead, two or three times less is sufficient, according to the different qualities of the object. But the mass will certainly be spilt, unless you choose a very good crucible; for there is no vessel charged with litharge, that can bear a strong fire having a draught of wind, without giving way through it to the litharge.

You add glass-gall and common salt, that they may forward the scorification, by swimming at top; for the refractory scoria rejected by the litharge, and adhering between this and the salts that swim

at top, is soon brought to a flux, and the precipitation of the silver is thereby accelerated. They also hinder a small burning coal, fallen into the crucible, from setting the litharge a-boiling, which troubles the operation; for the litharge, or glass of lead, especially that which is made without any addition, as soon as the carbon enters into it, rises into a foamy mass, consisting of a multitude of small bubbles, very difficult to be confined, unless the carbon be entirely consumed, and the litharge reduced to lead, which sometimes rises above the border of the vessel.

The following is given by Mr. Sage, as the best method of assaying ores of silver.

Melt a quintal of the roasted ore with as much litharge, and three quintals of common carbonat of potash, in a crucible, the bottom of which is lined with 24 or 30 grains of charcoal, softened with a little oil, so that the paste may be applied to the bottom, and half way up the side by the finger. Put on a cover, but without luting it. Place two such crucibles side by side in a common furnace, and cover them with charcoal. The bellows are not necessary. When the mixtures enter into fusion, which will readily be perceived by the ear, push the charcoal aside, so that you may be able to take off the lids, and see what is going on. If the effervescence raise the contents above the middle of the crucible, remove the lids, when the weight of the air will check the swell, and prevent it from running over. As soon as all is quiet, put on the lids again, cover up the crucibles with charcoal, and let them stand till they are cold If the assays have been well fused, the leads obtained will not differ in weight two grains. Subject them to cupellation, and you will obtain buttons, which ought not to differ a sixteenth of a grain. A sixteenth of a grain represents an ounce in a hundred pounds: but if the ore be so poor as to yield less than an ounce, as is the case with most of the mines, at present worked in America, the assay should be made with 400 grains at least.

Native metallic silver may be separated from the stones and earths with which it is intermixed by amalgamation with mercury, which operation is to be performed in the same manner as in the separation of native gold.

Ores of Tantalium.

Of these only two have yet been found, in both of which the metal is in the state of oxide. One of them was mistaken for an ore of tin, till it was analysed by Ekeberg.

Ores of Tellurium.

The ores of this lately discovered metal have yet been found only in the gold mines of Transylvania. In all of them the metal is in the state of an alloy, being combined with gold in every species, though but with a very minute portion in the native tellurium, formerly known by the name of *aurum paradoxicum,* which contains 92.55 of tellurium, and 7.20 of iron, in the hundred parts. In the graphic gold ore, yellow gold ore, and foliated or black ore, it is united with silver likewise. In the second and third of these there is a considerable portion of lead, and some sulphur: and the last contains a little copper also.

Ores of Tin.

The existence of native tin was long a matter of doubt among mineralogists. It has, nevertheless, been undoubtedly found in various places. Magellan, among other specimens, mentions, 1. Malleable tin in a granular form, and also foliaceous, bedded in a white hard matter, resembling quartz, but which, on proper examination, proved to be arsenic; a circumstance that evinces its being native tin, because the arsenic could not have retained this form, if the tin had undergone the fusing heat. It appeared like a thick jagged or scolloped lace or edging, and was found at St. Austel in Cornwall, England. 2. In the form of crystalline metallic laminæ, or flat crystals, rising side by side out of an edging, which shone like melted tin. They were nearly as thin as the leaves of talc, intersecting each other in various directions, with some cavities between them, within which appeared many specks and granules of tin that could easily be cut with a knife; this also came from Cornwall. 3. In a massy form, more than an inch thick in some places, and enclosed in a stone resembling quartz, which was taken to be a hard crust of crystallized arsenic.

All the ores of tin hitherto found, except the sulphuret from Huel or Wheal Rock, St. Agnes, Cornwall, are in the oxided state. They are remarkable for their great weight, which is between 5.8 and 6.97, according to Klaproth.

The common ore, called tin-stone, has a vitrified appearance, resembling a garnet of a blackish-brown colour, but much heavier. Its surface is shining, sometimes striated, and its fracture lamellar; soft enough to be cut or scraped with a knife, and affording a pale red powder. Some authors assert, that it contains arsenic, but Kirwan positively denies the existence of arsenic as a mineralizer of tin. The Germans call the irregular compact tin

ore by the name of zinnstein; but the crystallized tin-stones are called zinngraupen, if the crystals be distinct and somewhat large. The zinnzwitter ores, in which the crystals are small, and not so distinct, resemble small grains, scattered through a compact raw tin-stone, or a stone of any other kind.

The common matrix of tin in the Cornish mines is the killas, and the growan. This consists of white clay, mixed with mica and quartz, without any particular texture; which, when lamellar and hard, is called gneiss by the Germans, and is nothing else but decayed granite, in which the feltspar has been broken down to clay.

The zinngraupen, or brown crystallized tin-stone, from Cornwall, consists of quadrangular prisms, or double quadrangular pyramids, joined by their bases, so that these crystals are octoedral; these are found at Trwaunance and Soil-hole, in the parish of St. Agnes. Similar prismatic crystals, but of as small a size as a hair, are found in tin-stone upon killas, at Polgooth, one of the richest tin mines, which produces sometimes a clear profit from 1000 to 1200*l.* sterling per month.

The stream-tin is collected in the vallies of the tin mountains in Cornwall, and yields a considerable quantity of this metal. The soil is dug several feet deep, and washed by water going over it, till the heavier particles of the ore remain at the bottom. These are nothing else but the abrasions of the tin ores over the mountains, which are rolled down the declivities of the hills to lower grounds.

The stream-tin from Pensagillis is remarkable on account of the native gold now and then met with in it; and found, though very rarely, in pieces of the value of two or three pounds sterling. It principally consists of round, oval, and somewhat smooth pieces, from the size of a bean to that of a pea, and less, the polished surfaces of which show a variety of reddish, gray, light-brown, and dark yellow colours.

The wood-tin ore looks like hematites, and is found in the parishes of St. Columb, Roach, and St. Denis. This is without any crystallized form, and has a very inconsiderable quantity of iron with it.

Another wood-like tin ore, described by professor Brunnich, shows various fine fibres converging to different centres, like the radiated zeolyte; but is so compact and hard, as to strike fire with steel. Its specific gravity, at 45° of Fahrenheit, is 5.80, and even 6.45. It contains some arsenic and a considerable proportion of iron; and gives sometimes 63.5 per cent. of tin. It is very scarce, and found only in small pieces.

The tin spar, or white tin ore, is generally of a whitish or gray colour; sometimes it is yellowish, semitransparent, and crystallized, either of a pyramidal form, or irregular. It resembles a calcareous, or rather ponderous spar, but is easily known by its great weight, and shining greasy appearance. Its fracture also is vitreous. It was formerly thought to contain arsenic, but Margraaf found it to be the purest of all tin ores; though it is said to contain sometimes a mixture of calcareous earth. Its specific gravity is =6.007.

Tin grains are of a spherical polygonal figure, like the garnets; but seem more unctuous on their surface. It is found either in large or small grains.

Bergman received a specimen of native aurum musivum from Nerschinskoi in Siberia. It resembled the artificial aurum musivum externally, or rather the aurum musivum formed a crust environing a nucleus radiated in its fracture, and resembling a white metal. It yielded to the knife, and the place of section exhibited a variable colour. Its powder was black. By the analysis, it proved to consist of tin mineralized by sulphur, with a very small portion of copper. In the Journal de Physique for 1783, it is said, that the specimen was too small to admit of a determination of the quantities in the large way: but in the preface to the Sciagraphia it is said, that the native aurum musivum contained forty parts of sulphur to one of tin: and the other mineral, which resembled antimony, contained one fifth part of sulphur only.

At Huel Rock, in St. Agnes, in Cornwall, there has been found a metallic vein nine feet wide, at twenty yards beneath the surface. Raspe was the first who discovered this to be a sulphuret of tin: it is very compact, of a blueish white colour, approaching to gray steel, and similar to the colour of gray copper ore: it is lamellar in its texture, and very brittle. It consists of sulphur, tin, copper and some iron. Raspe proposes to call it bell-metal ore.

According to Klaproth's analysis of this ore, 100 parts contain 25 of pure sulphur, 34 of tin, 36 of copper, two of iron, and three grains of the stony matrix. A faint smell of arsenic was perceptible in roasting it. The darker varieties, however, are much poorer in tin, and contain more iron.

Bergman's method of assaying tin ores in the humid way is too commonly ineffectual. Klaproth gives the following

mode. Mix the ore, in fine powder, with a lixivium containing six times its weight of caustic potash; evaporate to dryness, in a silver vessel, on a sand heat; and then keep in a state of moderate ignition for half an hour. Dilute the mass, while yet warm, with boiling water, and filter. Let the residuum be again ignited with six times its weight of potash, and dissolve in boiling water, as before. Mix the solutions, and add muriatic acid, till the precipitate, which falls down, is dissolved by its excess. Separate the tin from the acid by carbonat of soda; wash the precipitate; dry it; and re-dissolve it in muriatic acid by a gentle heat. Into the colourless solution, diluted with two or three parts of water, put a stick of zinc, and in a few days the whole of the tin will gather round it in dendritic laminæ. The residuum left after the second solution is to be treated with muriatic acid, and what tin is in it precipitated by zinc in the same manner. If it contain any iron, this may now be precipitated by prussiat of potash.

The sulphuret requires to be treated somewhat differently. To one part of the powdered ore add four of muriatic, and two of nitric acid, and after they have stood together 24 hours, digest for some time in a gentle sand heat; then dilute with a little water, and filter. Let the sulphur of the residuum be burned off on a test, and treat what remains with fresh nitro-muriatic acid. The part not soluble being ignited with a little wax, the iron will be reduced, and the remainder is silex from the matrix. The solutions are to be precipitated with carbonat of potash; the precipitate redissolved in muriatic acid diluted with three parts of water; and a stick of pure tin immersed in this solution. The copper will be deposited on the tin, and leave the solution colourless. The copper being dissolved by brisk digestion in nitric acid, if any tin be mixed with it, this will fall down in the state of white oxide. The tin may be separated by zinc, as in the preceding instance; and what was dissolved from the stick used in precipitating the copper, must be deducted from its weight.

In the dry way, these ores, after pulverization and separation of the stony matter by washing, are to be melted with a mixture of double their weight of a flux, consisting of equal parts of pitch and calcined borax, in a crucible lined with charcoal, and to which a cover is luted; fusion should be speedily procured.

Bergman recommends a mixture of one part of the ore with two of tartar, one of black flux, and half a part of resin: this is to be divided into three parts, and each successively projected into a crucible heated white, and immediately covered after the foregoing portion ceases to flame; the whole operation takes up but 7 minutes, or less.

Previous to smelting in the large way, the impure ores of tin must be cleansed as much as is possible from all heterogeneous matters. This cleansing is more necessary in ores of tin than of any other metal, because in the smelting of tin ores a less intense heat must be given, than is sufficient for the scorification of earthy matters, lest the tin be oxided. Tin ores previously bruised, may be cleansed by washing, for which operation their great weight and hardness render them well adapted. If they be intermixed with very hard stones, or ferruginous ores, a slight roasting will render these impure matters more friable, and, consequently, fitter to be separated from the tin ores. Sometimes these operations, the roasting, contusion, and lotion, must be repeated. By roasting, the ferruginous particles are so far revived, that they may be separated by magnets.

The ore, thus cleansed from adhering heterogeneous matters, is to be roasted in an oven, or reverberatory furnace, with a fire rather intense than long continued, during which it must be frequently stirred to prevent its fusion. By this operation the arsenic is expelled, and in some works is collected in chambers built purposely above the oxiding furnace.

Lastly, the ore cleansed and washed is to be fused, and reduced to a metallic state. In this fusion, attention must be given to the following particulars:

1. No more heat is to be applied than is sufficient for the reduction of the ore, because this metal is fusible with very little heat, and is very easily oxidable.

2. To prevent this oxidation of the reduced metal, a larger quantity of charcoal is used in this than in the other fusion.

3. The scoria must be frequently removed, lest some of the tin should be involved in it; and the melted ore must be covered with charcoal powder, to prevent the oxidation of its surface.

4. No flux or other substance, excepting the scoria of former smeltings which contains some tin, are to be added, to facilitate the fusion.

Ores of Tungsten, and *Ores of Uranium*, are not much known.

Ores of Zinc.

This metal has not been found in a native state.

All the ores of zinc tinge plates of cop-

per of a yellow colour, when stratified with that metal and charcoal: but for this purpose the sulphureous ores must be previously roasted. The ores of zinc are either oxides, carbonats, sulphats, or sulphurets.

Mr. Steinhauer, of Fulneck, says, that a native oxide, scarcely inferior to the flowers of zinc of the shops, is found in considerable quantity in the West-riding of Yorkshire, England. In general it is mixed with iron, silex, and alumine in variable proportions, and is known by the name of calamine.

Its colour is white, gray, yellow, brown or red, and of various degrees of hardness, though scarce ever so hard as to strike fire with steel; its texture equable or cellular, and its form either irregular, crystallized, or stalactitical; when calcined it loses no part of its weight, except it be mixed with charcoal, and then flowers of zinc sublime; it is soluble in acids, and with the sulphuric affords sulphat of iron as well as of zinc, which shows the iron it contains is not much oxided. The specific gravity of the best sort, that is, the gray, is 5: 100 parts of this afforded Bergman 84 of oxide of zinc, 3 of iron, 1 of alumine, and 12 of silex; but in other specimens these proportions are very different; some ores are so poor as not to contain above 4 per cent. of oxide of zinc; a good ore should afford at least 30 per cent., and its specific gravity be about 4.4 or 5.

Sometimes calamines contain a mixture of calcareous earth and lead. Indeed most of the English calamines contain lead.

Bergman gives us two methods of analysing calamine. The first is to oxide it in the nitric acid with the assistance of heat, and boil away the acid to dryness. Repeat this operation twice or thrice, using each time twice as much of the acid as the ore weighs; and lastly, dissolve all that is soluble in a fresh portion of nitric acid: by this means the zinc (and lead if any) with the alumine will be taken up, while the iron, being highly oxided, will, with the silex, remain undissolved. If the solution contain lead, the muriatic acid will precipitate it; after which the sulphuric may be used to precipitate the lime, if any be contained in the ore, or the lead and other metals may be precipitated by adding a piece of zinc. The zinc may then be precipitated by the prussiat of potash, the weight of which, divided by five, gives that of zinc in its metallic form contained in the ore. The undissolved residuum should be treated with three times its weight of concentrated sulphuric acid, and evaporated to dryness, and all that is soluble extracted with warm water; the iron should be precipitated by the prussiat of potash, and the alumine by the carbonat of soda, which should also be added to the nitric solution after the zinc is precipitated.

The second method is shorter and more ingenious. He distills the sulphuric acid over calamine to dryness; the residuum he lixiviates in hot water; what remains undissolved is silex; to the solution he adds pure ammonia, which precipitates the iron and alumine, but keeps the zinc in solution, as it is soluble in sulphat of ammonia: the precipitate he redissolves in sulphuric acid, and separates the iron and alumine as before.

In the ore of tutenague the oxide of zinc is mixed with a notable proportion of iron. Engestrom, in the Memoirs of Stockholm for the year 1775, has given us an analysis of an ore of this sort from China; it was of a white colour, interspersed with red streaks of oxide of iron, and so brittle as to be easily broken betwixt the fingers. It was soluble in the mineral acids, particularly with the assistance of heat; and with the sulphuric afforded sulphats both of zinc and iron; the quantity of carbonic acid was so small as to be absorbed by the solution; it contained in various specimens from 60 to 90 per cent. of zinc; the remainder was iron and a small proportion of alumine. Bindheim also discovered this variety in Germany, and found it to consist of zinc, a little iron, and silex.

Of a similar nature appears to be a singular mineral lately discovered in the mine of Fahlun, in Sweden, by Mr. Gahn, and thence called Gahnite zinc by Brongniart. It is the *automalite* of Eckeberg; zinciferous corundum of Hissinger. In its properties it approaches the spinel and ceylanite. It is crystallized in very regular octoedra; sufficiently hard to scratch quartz; a non-conductor of electricity; infusible by the blowpipe alone, but with borax melts into a green glass, that becomes colourless on cooling. The crystals are small. Their longitudinal fracture foliated, transverse, uneven, and somewhat conchoidal. Their specific gravity, according to Eckeberg, 4.261; according to Haüy, 4 697

Eckeberg, who first analysed this mineral, gives as its constituent parts, oxide of zinc 0.24, alumine 0.60, silex 0.05, iron 0.09, sulphur and loss 0.02. Vauquelin found in it oxide of zinc 0.28, alumine 0.42, silex 0.04, iron 0.05, sulphur and loss 0.17; beside 0.04 of the stone, that remained unaltered.

The vitreous zinc ore, or zinc spar, is a carbonat of zinc, of a whitish-gray, blueish-gray, or yellowish colour, and of a hardness generally sufficient to strike fire with steel. In its fracture it resembles quartz, irregular, stalactitical, or crystallized in groups, and weighty; by calcination it loses one third of its weight, without emitting a sulphureous or arsenical smell, and is infusible in the strongest heat, either singly, or with soda, but easily fusible with borax or microcosmic salt. In the mineral acids it is soluble with effervescence, and with the sulphuric affords sulphat of zinc. One hundred grains of this ore contain about 65 of the oxide of zinc, 28 of carbonic acid, six of water, and one of iron; and sometimes a little of silex.

Bergman suspects the substance called zinc spar by Baron Born to be a different substance. Bindheim found it insoluble in acids before calcination, and in the dry way infusible with the three usual fluxes; but after calcination it becomes soluble in acids.

Haüy found, that the crystallized native oxide of zinc is rendered electric by heat without friction.

The zeolitiform ore of zinc is a carbonat mixed with a notable proportion of silex. The real contents of this substance were first discovered by Pelletier. It was long taken for a zeolite, being of a pearl colour, crystallized, semitransparent, consisting of laminæ diverging from different centres, and becoming gelatinous with acids. It was commonly called zeolite of Friburgh. He found 100 grains of it to contain from 48 to 52 of quartz, 36 of carbonat of zinc, and eight or 12 of water.

These ores are easily analysed in the moist way, by dissolving them in the dilute sulphuric acid: the silex, if any, will remain undissolved; and the zinc and iron are taken up, and may be separated by adding a piece of zinc previously weighed, and boiling the solution; by which the iron will be precipitated. The solution, which then contains only zinc, should be precipitated by carbonat of soda. One hundred and ninety-three grains of this precipitate are equivalent to 100 of zinc in its metallic form, from which the weight lost by the inserted zinc should be subtracted; the weight of the carbonic acid and water may be collected by comparing the loss of weight which the ore suffers by calcination and solution in acids.

Of the ores of zinc which are mineralized by sulphur, or ore blendes, there are several varieties. They are generally of a lamellar or scaly texture, and frequently of a quadrangular form, resembling galena; they all lose much of their weight when heated, and burn with a blue flame; their specific gravity is inferior to that of galena. Almost all contain a mixture of lead ore; most of them exhale a sulphureous smell when scraped, or at least when sulphuric or muriatic acid is dropped on them. Werner divides them into three species by their colours; the yellow, brown, and black.

The phosphorescent blende is generally greenish, yellowish-green, or red, of different degrees of transparency, or opake. When scraped with a knife in the dark, it emits light, even in water; and after undergoing a white heat, when distilled *per se*, a siliceous sublimate rises, which shews it contains the sparry acid, probably united to a metal, since it sublimes. It is almost wholly soluble in the muriatic acid in a boiling heat.

Bergman found 100 parts of that of Scharfenberg to contain 64 of zinc, five of iron, 20 of sulphur, four of fluor acid, six of water, and one of silex.

A sulphuret of zinc was lately met with in one of the Gwennap mines, incrusting a spongy pyrites intermixed with quartz, and so like wood-tin, as to be supposed a variety of it by the miners. According to Dr Kidd, it consists of 66 oxide of zinc, 33 sulphur, and a very minute portion of iron. The pyrites contains cobalt.

In the dry way zinc is reduced by distilling its ore after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, and a strong heat: but by this method scarce half the zinc it contains is obtained.

The first dressing of calamine for the large works of zinc consists in picking out all the pieces of lead ore, lime, and ironstone, cauk, and other heterogeneous substances, which are found mixed with it in the mine: it is then roasted in proper furnaces, where it loses about a third or fourth part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more discernible, by the action of the fire; it is then ground to a fine powder, and washed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; so that, by these processes, a ton of the crude calamine of Derbyshire is reduced to 12 cwt. only.

Bergman affirms, that a certain Englishman, whose name he does not mention, made, several years ago, a voyage to China, for the purpose of learning the

art of smelting zinc, or tutenague; and that he became instructed in the secret, and returned safely home.

It is not improbable, but that a fact of this kind may have served to establish the manufactory of zinc in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the first work of the kind near Bristol. It consists, as Watson relates, of a circular kind of oven, like a glass-house furnace, in which were placed six pots, of about four feet each in height, much resembling large oil-jars in shape; into the bottom of each pot is inserted an iron tube which passes through the floor of the furnace, into a vessel of water. A mixture of the prepared ore is made with charcoal, and the pots are filled with it to the mouth, which are then close stopped with strong covers, and luted with clay. The fire being properly applied, the metallic vapour of the calamine issues, downwards, or *per descensum*, through the iron tubes, there being no other place through which it can escape; and the air being excluded, it does not take fire, but is condensed in the water into granulated particles; which, being remelted, are cast into ingots, and sent to Birmingham under the name of zinc, or spelter; although by this last name of spelter, only a granulated kind of soft brass is understood among the braziers, and others who work in London, used to solder pieces of brass together.

Great part of the zinc volatilized by the force of fire, in large furnaces, as those at Goslar, adheres to their sides in the form of a whitish oxide: this is scraped off when the furnace is cold, and is called by the name of ofenbruch, or cadmia, which is employed, as well as zinc, to make brass.

Centner, or *Docimastic Hundred*, in Metallurgy and Assaying, is a weight divisible, first into an hundred, and thence into a greater number of other smaller parts; but though the word is the same, both with the assayers and metallurgists, yet it is to be understood as expressing a very different quantity, in their different acceptation of it. The weights of the metallurgists are easily understood, as being of the common proportion, but those of the assayers, are a thousand times smaller than these, as the portions of metals or ores examined by the assayers, are usually very small.

The metallurgists, who extract metals out of their ores, use a weight divided into an hundred equal parts, each part a pound; the whole they call a centner or hundred weight; the pound is divided into thirty-two parts, or half ounce; and the half ounce into two quarters of ounces, and these each into two drachms.

These divisions and denominations of the metallurgists are easily understood; but the same words, though they are equally used by assayers, with them express very different quantities; for as the centner of the metallurgists, contains a hundred pounds, the centner of the assayers, is really no more than one drachm, to which the other parts are proportioned.

As the assayers' weights are divided into such an extreme degree of minuteness and are so very different from all the common weight, the assayers usually make them themselves, in the following manner, out of small silver, or fine solder plates, of such a size, that the mark or their weight according to the division of the drachm, which is the docimastic, or assaying centner, may be upon them. They first take for a basis one weight, being about two-thirds of a common drachm: this they mark (64lb.) Then having at hand some granulated lead, washed clean, well dried, and sifted very fine, they put as much of it in one of the small dishes of a fine balance, as will equipoise the 64lb. (as it is called) just mentioned: then dividing this granulated lead into very nice halves, in the two scales, after taking out the first silver weight, they obtain a perfect equilibrium between the two scales; they then pour the granulated lead out of one dish of the scales, and instead of it, put in another silver weight, which they make exactly equiponderant with the lead in the other scale, and mark it (32lb.) If this second weight, when first put into the scale, exceed by much the weight of the lead, they take a little from it by a very fine file: but when it comes very near, they use only a whetstone, to wear off an extremely small portion at a time. When it is brought to be perfectly even and equal to the lead, they change the scales to see that no error has been committed, and then to go on in the same manner, till they have made all the divisions, and all the small weights. Then to have an entire centner or hundred weight, they add to the 64lb. (as they call it) a 32lb. and a 4lb. and weighing against them one small weight, they make it equal to them, and mark it (101b.) This is the docimistical, or assaying centner, and is really one drachm. Cramer, Art. Ass. p. 108.

ORIENTAL.—Precious stones from the East have been supposed to be harder and more brilliant than those which come from South America. How far this may

really be the case, is not perhaps easy to be determined. Jewellers use the words oriental and occidental to denote the superior or inferior quality of a gem, without giving themselves any trouble about the place it came from. Thus an oriental topaz is one of the best, whether it comes from the East Indies or not; and the inferior stones or coloured quartz are called occidental topazes, though some of them perhaps may come from the East.

ORIGANUM.—An essential oil is kept in the shops under the name of the oil of origanum, which is obtained from the leaves of the origanum vulgare Linnæi, or wild marjoram. See ORE.

ORPIMENT.—A combination of arsenic with sulphur, of a yellow colour. See COLOUR-MAKING.

ORRIS.—The dry roots of the Florence iris or oris (iris alba Florentina, C. B.) are entirely mild, and said to be a medicine of good service in disorders of the breast. They have a pleasant sweet smell resembling that of violets, and hence are employed in sweet-scented powders, for flavouring liqueurs, &c. The distilled water smells a little of the root, but exhibits no appearance of oil: the distilled spirit also has some slight smell. The strongest preparation both in smell and taste is the spirituous extract, this containing nearly all the active parts of the root concentrated into a small volume. An ounce of the root yielded a drachm and 17 grains of spirituous, and afterward a drachm and 40 grains of watery extract: water applied at first extracted from the same quantity three drachms, and spirit afterward only eight grains. The extract made by water at first both tastes and smells of the orris, though not near so strongly as the spirituous.

OSMIUM.—A new metal lately discovered by Mr. Tennent among platina, and thus called by him from the pungent and peculiar smell of its oxide.

Its oxide may be obtained in small quantity by distilling with nitre the black powder left after dissolving platina; when at a low red heat an apparently oily fluid sublimes into the neck of the retort, which on cooling concretes into a solid colourless, semitransparent mass. This being dissolved in water, forms a concentrated solution of oxide of osmium. This solution gives a dark stain to the skin, that cannot be effaced. Infusion of galls presently produces a purple colour in it, which soon after becomes of a deep vivid blue. This is the best test of the oxide. With pure ammonia it becomes yellow, and slightly so with carbonat of soda. With lime it forms a bright yellow solution; but it is not affected either by chalk or by pure magnesia. The solution with lime gives a deep red precipitate with galls, which is turned blue by acids. It produces no effect on solution of gold or platina; but precipitates lead of a yellowish brown, mercury of a white, and muriat of tin of a brown colour.

OSMUNDIC EARTH. See EARTH, FULLERS.

OSTEOCOLLA, is a substance formed by stony matters filling up the interstices of rotten roots of trees. It has been particularly described by Mr. Gleditsch, and examined chemically by Mr. Margraaf. See Memoirs of the Berlin Academy for the year 1748. The former author relates, that it is dug from grounds containing fine sand and a fine calcareous earth; and that sometimes the roots of living trees had been found converted into this stony substance. From Margraaf's experiments it appears, that the osteocolla examined by him was composed of a fine sand, a fine calcareous earth, and some rotten remains of a root. Neuman says, that he found muriatic acid in osteocolla. But nothing of that or any other acid could be discovered by Margraaf. Neumann also says, that he totally dissolved osteocolla by means of dilute sulphuric acid. Hence the substances examined by these two chemists seem to have been different. Differences must arise from the different qualities of the soil in which osteocolla is found.

OSTRICH'S DOWN, called otherwise ostrich's hair, and sometimes wool, is of two sorts; that called the fine of ostrich, is used by hatters in the manufacture of common hats; and that called coarse of ostrich, serves for the making of list for fine white cloth.

OTTA, or ATYR OF ROSES.—The essential oil of roses. It comes to us under this name from Bengal, and is of too high price to become an article of commerce in England. From a variety of accounts we learn, that it is obtained in the usual method, viz. by the distillation of rose leaves with water, and that a prodigious quantity of roses affords but a small proportion of the oil. It is said to be equal in fragrance to a new-blown rose. This perhaps may be true of the oil when newly distilled; but in the few specimens which have come under our observation, the difference in scent appears to be nearly as great as between most other essential oils and the vegetables which afford them. See OIL.

OVEN.—A kind of domestic furnace, used for baking bread, pies, tarts, &c.

Ovens are generally constructed of

brick-work in a semi-circular form, with a very low roof, and the bottoms are laid with stone: in the front is a small aperture and door, by the shutting of which, the heat is confined while the bread is baking. They are usually heated by means of dry faggots, wood, &c. As these ovens, however, are not calculated for small families, on account of the quantity of fuel they consume, others have been contrived, on a more diminutive scale: these are usually formed of cast or hammered iron, and may be heated by the same fire which serves for the cooking of other provisions.

Among the ovens of this construction, that of Mr. Powers, who obtained for it a patent in 1801, deserves to be noticed. It is formed of iron, so as to be portable, and may be conveniently conveyed to any distance, at the option of its possessor; but, as the reader cannot form a distinct idea of this contrivance, without the aid of an engraving, we refer him to the 14th vol. of the Repertory of Arts, &c. where the patent is described, and illustrated with a plate.

In the year 1800, the London Society for Encouragement of Arts, &c. conferred a bounty of 15 guineas on Mr. S. Holmes, for his invention of an oven, which is heated without flues. The whole consists of a cast-iron stove, from the side of which a solid piece of that metal projects into the fire, where it constantly remains; and, on becoming red-hot, communicates to the whole oven a degree of heat sufficient for baking bread. while it at the same time assists the fire in roasting the meat.

In the common iron ovens, the heat is communicated by means of flues, which waste a considerable part of the fire in its passage, and likewise require much labour to keep them of an uniform heat. The contrivance last alluded to, is intended to supply this and other inconveniences: and Mr. Holmes states, that his oven uniformly remains at a baking heat, without any additional expense, or trouble. We understand, however, that such improvement is by no means *new;* and that a similar method of saving fuel, has for several years been practised in the west of England.

This subject will probably be noticed under the article Stove.

OYSTER SHELL LIME.—The shells of the oyster, like those of other crustaceous fish, are composed of calcareous earth, and animal glue. They possess no medicinal virtue superior to common limestone or chalk; but, by calcination, they yield a quick-lime, which is perfectly free from any metallic or other fossil substance; and being less permeable to water, when mixed with sand, it is better calculated for the plaistering of walls in damp situations. Hence the Dutch prepare their excellent mortar generally of marine shells burnt into lime; which makes a most durable cement. The great importance of this fact, in point of health and economy, deserves equal attention; so that the immense quantities of oyster-shells annually thrown away in cities, might easily be converted into a very useful *shell-lime.*

It is a custom in different parts of the United States, where lime-stone is scarce, and marine shells in abundance, to produce lime by the calcination or burning of shells. For this purpose, the oyster-shell is used.

In New-Orleans, this practice is common; and excellent lime is obtained. We think, that however cheap lime may be which is procured from lime-stone, even in our cities, the burning of oyster-shells would repay the expense, and yield a handsome profit. The quantity of shell is immense, although at first view they would appear few.

OX. See Animals, Domestic.

OXYGEN GAS.—As we have noticed oxygen very frequently, we shall here say something on the subject.

This gas was obtained by Dr. Priestley in 1774 from red oxyde of mercury, exposed to a burning lens, who observed its distinguishing properties of rendering combustion more vivid and eminently supporting life. Scheele obtained it in different modes in 1775; and in the same year Lavoisier, who had begun, as he says, to suspect the absorption of atmospheric air, or a portion of it, in the calcination of metals, expelled it from the red oxyde of mercury heated in a retort. Priestley, agreeably to his theory, called it *dephlogisticated air;* Scheele, from its peculiar property, *fire air,* a name before given it by Mayon, or *empyreal air;* Lavoisier, air eminently pure, and afterward eminently respirable, which Condorcet altered to *vital air*; a term to which perhaps there is no objection, but its intractability when wanted in compound names. Bergman's term, pure air, as well as Lavoisier's eminently pure, is not distinctive. When the French chemists commenced their complete system of reform of the chemical nomenclature, finding the bases of this gas present in every compound that possessed acid properties, and considering it as the acidifying principle, they gave it the name of *oxygen,* which it still retains, notwithstanding some anomalies

with regard to this quality have since been observed.

Oxygen gas forms about a fourth of our atmosphere, and its base is very abundant in nature. Water contains .85 of it: and it exists in most vegetable and animal products, acids, salts, and oxydes.

This gas may be obtained from nitrat of potash, (common saltpetre) exposed to a red heat in a coated glass or earthen retort, or in a gun barrel; from a pound of which about 1200 cubic inches may be obtained; but this is liable, particularly toward the end of the process, to a mixture of nitrogen. It may be expelled, as already observed, from the red oxyde of mercury, or that of lead; and still better from the black oxyde of manganese, heated red-hot in a gun barrel, or exposed to a gentler heat in a retort with half its weight, or somewhat more, of strong sulphuric acid. To obtain it of the greatest purity, however, the hyperoxymuriat of potash is preferable to any other substance, rejecting the portions that first come over, as being debased with the atmospheric air in the retort. Growing vegetables, exposed to the solar light, gave out oxygen gas; so do leaves laid n water in similar situations, the green matter that forms in water, and some other substances.

Oxygen gas has neither smell nor taste. It is a little heavier than atmospheric air. Under great pressure water may be made to take up about half its bulk. It is essential to the support of life: an animal will live in it a considerable time longer than in atmospheric air; but its respiration becomes hurried and laborious before the whole is consumed, and it dies, though a fresh animal of the same kind can still sustain life for a certain time in the residuary air.

Combustion is powerfully supported by oxygen gas. Any inflammable substance, previously kindled, and introduced into it, burns rapidly and vividly. If an iron or copper wire be introduced into a bottle of oxygen gas, with a bit of lighted touchwood or charcoal at the end, it will burn with a bright light, and throw out a number of sparks. The bottom of the bottle should be covered with sand, that these sparks may not crack it. Mr. Accum says, a thick piece of iron or steel, as a file, if made very sharp at the point where it is first kindled, will burn in this gas. If the wire, coiled up in a spiral like a corkscrew, as it usually is in this experiment, be moved with a jerk the instant a melted globule is about to fall, so as to throw it against the side of the glass, it will melt its way through in an instant.

OXYGENATION.—The process of combining oxygen with bodies: such bodies as are thus combined with oxygen, are said to be oxygenated, or oxygenized. Very frequently the combination forms an acid; the base is therefore acidified; and sometimes oxydized, forming therewith an oxyd.

OXYDIZEMENT.—The forming of an oxyd, by the combination of a base with oxygen: the name of the process.

OXYGENIZED MURIATIC ACID.—This acid called also dephlogisticated muriatic acid, is extensively used in some of the arts, as in bleaching. It is not necessary to go into an explanation of its properties in general; but the following observations, we deem sufficient.

It may be made by adding two parts of muriatic acid, to one of finely powdered manganese, in a retort connected with Woulfe's apparatus, and applying a gentle heat to it, while the receivers are surrounded by water, as near as possible to the freezing point: or by mixing 8 parts of muriat of soda, (common salt) with 3 of powdered manganese, putting them into a retort, pouring on them four parts of sulphuric acid, previously diluted with an equal weight of water, and proceeding as above. The operator should be very careful, that none of the acid escapes into the air, in the state of gas, as it is very injurious when respired, occasioning all the symptoms of violent catarrh, by coming into contact with the membrane, that lines the nostrils, and severe stricture and oppression of the chest, if it enter the lungs. The best preventive of its mischievous effects, when it does thus escape, is the vapour of volatile alkali, for which it has a powerful affinity.

When the water in the receivers is kept at a temperature below 40°, the water not only saturates itself with the gas, but crystals, of a shining greenish white, form in hexaedral scales on the surface, and round the sides, enclosing the fluid, till the whole assume a gelatinous appearance. A very moderate heat melts the concrete matter, and even converts it into a gass, that rises in bubbles through the saturated fluid, and floats on its surface. By increasing the heat, the whole of the gass may be expelled with very little alteration; but light decomposes it, and reduces it to the state of common muriatic acid, by liberating the oxygen.

It is a singular circumstance, that one of the powerful mineral acids, should be deprived of what are considered as characteristic properties of an acid, by the addition of oxygen, which is deemed the acidifying principle. Its taste, instead of being sour, is harsh and styptic; and in-

stead of reddening blue vegetable colours it destroys them, as it does most others, yellow excepted. From this property, it is of use for removing stains, and discolorations from old books and prints; though it is destructive to manuscrips, as it discharges writing ink; and it is very extensively employed in bleaching, as will be seen more at large under that article. In medicine too it has been tried. Van Deiman recommends it in a dilute state, against the itch and scald-head, and as a wash for the gums when scorbutic: Fourcroy mentions it as a powerful tonic: and Mr. Brathwaite of Lancaster, (England) extols it highly in doses of 10 or 15 drops against scarlet fever. But we are not inclined to give it credit, for any decided superiority over other acids, that can be obtained and administered more commodiously.

The application of this acid to bleaching in particular, with the apparatus used in modern bleaching, as well as its preparation on a large scale, may be seen in the Appendix to vol. 1. See also BLEACHING.

OXYMURIATE OF LIME. Salt used in bleaching, see Appendix, vol. 1.

OXYMURIATIC OF MAGNESIA.—Salt used in bleaching, see Appendix, vol. 1.

P.

PAPER, *Bleaching of*.—The bleaching of paper, or paper stuff, with oxymuriatic acid, has been recommended by Mr. Cist in Cooper's Emporium. Mr. C. observes, "as the bleaching, by means of the oxymuriatic acid is, I believe, not known or in use in our paper-mills, it may be useful to the profession here to be informed of the mode and process of conducting in Europe that part of their business," which he gives in a plain and familiar manner. The mode of making the bleaching liquor is the same as given under BLEACHING, and in the Appendix to vol. i: the proportions of the materials in the latter are, however, more accurate. After the observations of Mr. C. which, he says, were furnished him by an English manufacturer, the professor concludes with some judicious remarks, which, in his usual manner, display much thought and erudition.

Citizen Loysel, in the Ann. de Chim. xxxix, page 137, has a memoir on the method of bleaching the paste of paper. With respect to the choice and preparation of rags, he gives the following remarks.

"The strength or tenacity of paper depends upon the staple or fibre of the material from which it is made. Rags of new cloth and cordage compose a paper more tough than old rags, and the first of these materials presents a great variety, on account of the quality of the hemp or flax of which they are formed. Rags of fine new cloth, whether raw or bleached by the oxigenated muriatic acid, stand in the first rank, after which cordage and old rags may be classed.

Paper intended for bills of exchange, or other commercial and legal instruments, ought to be tough, in order that it may not be easily torn when thin; for this paper the materials of the first class must be entirely, or in large proportion, employed. The price which consumers are disposed to pay for this article, is sufficient to indemnify the manufacturer for his care and industry, as this kind of paper is sold in France for five or six francs the kilogram.

The other papers also require to be more or less tough, according to their thinness, and the use to which they are applied, but a clear white colour is sought in paper of every description. The first operation to which the rags are subjected is sorting, in order that each branch of the manufacture may have its appropriate material, after which they are cut with shears into pieces of about one decimeter, or three or four inches square.

I will suppose that the object of the manufacturer is to obtain paper of a beautiful white. If it is intended to be thin, so that, for example, a ream of the size denominated *raisin*, should weigh only four or five kilograms, that is to say, about one-third of the weight of common paper of the same form. The manufacturer makes choice either of new rags already of a fine white, or of unbleached rags.

In the case of the white rags, it is sufficient to pass them under the first cylinder, then to give them a bath of the bleaching liquor, and afterwards a bath of sulphuric acid, as we shall proceed to direct; after which they are passed under

the finishing cylinder for seven or eight hours; and, lastly, conveyed to the working trough to be made into sheets of paper.

Rags, which have never been bleached, may be treated by either of the following processes, that is to say, the first, which preserves the utmost degree of toughness to the paper, but is likewise the most expensive, consists in decomposing the rag, and afterwards applying the method of citizen Bertholiet for bleaching piece-goods; namely, subjecting it to three or four lixiviations, and afterwards alternately to lixiviations, baths of the bleaching liquor, and baths of sulphuric acid. The weight of the raw unbleached material is diminished from 50 to 45 per cent. in these operations

This method was the first which we used for the assignat paper; but we soon perceived that we might omit most of the lixiviations and baths of the bleaching fluid, and still preserve as much toughness as the paper required. Nothing further was necessary for this purpose than to suffer the rag to undergo a degree of fermentation more or less advanced, by leaving it to rot. In this operation the colouring matter undergoes a slow combustion, and passes to a kind of saponaceous state, and is carried off by the water, by washing the rags in the vessel of the first cylinder.

One single lixiviation, two baths of the bleaching liquor, and one of sulphuric acid, are then sufficient to bleach completely the raw rags or cordage. This is the second method. We were not, at that time, acquainted with the economical process of citizen Chaptal in the operations of lixiviation. This will, no doubt, be used; but the effect of rotting, carefully conducted, will always be found very advantageous.

Lastly, if the rags be neither perfectly white nor raw, and unbleached, but in a medium state, they are left to rot for a shorter time, for example, twelve or fourteen days, and are taken up when the heat of the fermentation raises the thermometer to 30 or 35 degrees, after which the process is to be conducted as before mentioned."

PAPER-HANGINGS, are a particular kind of paper, which is much thicker than that used for the purposes of printing, writing, &c.; so that it is manufactured solely for hanging or lining the walls of rooms. Such papers are coloured in various ways; but, as a description of these processes would trespass on our limits, we shall merely take notice of a patent, which was granted in 1793, to Mr. Eckhardt, for his method of preparing and printing paper-hangings in different patterns, and silvering them so as to resemble damask, lace, and various silk stuffs. The patentee directs the paper to be coloured in the usual manner, and a proper coat of size, consisting of solutions of isinglass, or parchment, to be applied. When this *ground* is sufficiently dry, a gold size, or other preparation, may be substituted, and laid on those parts, on which the ornaments are intended to appear. Before the gold size is perfectly dry, leaves of silver are spread over it; the paper is sized two or three times; and then finished with such varnish as will resist moisture.

PAPER-MAKING. Paper is a word evidently of Greek origin, from *papyrus*, the name of a celebrated Egyptian plant, which was so much used by the ancients in all kinds of writing.

We conceive it unnecessary to describe particularly the different expedients which men in every age and country have employed for giving stability to their ideas, and for handing them down to their children.

On the first discovery of the art of writing, stones, bricks, leaves of trees, the interior and exterior bark, plates of lead, wood, wax, and ivory, were employed. The progress of society, and the consequent improvement in the arts, produced Egyptian paper, paper of cotton, paper made from the bark of trees, and in our times from old rags.

To the most approved method of manufacturing paper from this latter material we shall confine ourselves; and to give a concise view of this subject, it will be necessary to proceed with all the important parts of the operation in their order.

The selection of the rags, is the arranging of them into different lots, according to their quality and to the demand of the paper-mill. In general, this selection is very much neglected: The degrees of fineness and whiteness, distinguished with little care, are thought to be the only objects of importance; whereas the hardness and softness, the being more or less worn, are very essential in this selection. It is certain, that a mixture of soft and hard rags occasions much more loss in the trituration, than a difference in point of fineness or of colour. This exactness in the selection is still more necessary, where cylinders are used instead of mallets. We cannot do better than to give the method practised in Holland as worthy of imitation.

They begin by a general separation of the rags into four lots; superfine, fine,

middle, and coarse. These lots are given to selectors, who subdivide each of them into five chests. They have besides a bench, on which is fixed vertically a hook, and a piece of scythe which is terminated by a crooked point.

The person, for example, who has the charge of the fine lot, puts into one of the chests the hard rags, or those which are little used, into another the soft, into a third the dirty, into a fourth those which are stitched or hemmed, and, finally, into the fifth the superfine rags which happens to be among the fine.

After this process, the women who have the charge of it are at extreme pains to pick out every kind of sewing, and especially the knots of thread and the hems, by means of the hook or scythe which they have under their hands. They take care also by the same means to cut and reduce the rags exactly by the warp and the woof into small pieces. It is of great advantage to cut or tear the pieces of rags by a thread, whether it be by the warp or woof; because, if it is done obliquely, many of the ends are lost in the operation.

When they have selected a certain quantity of each of these subdivisions, they are placed on an iron grate, which covers a large chest where they are beat, and otherwise turned, till the filth and dust pass through the bars of the grate and fall into the chest.

The number of lots in the selection of rags must be proportioned to the mass from which the selection is made, and to the kinds of paper produced by the mill. Some mills, the work of which is considerable, make nine lots of their rags, five of which respect the fineness, and the rest the cleanness and the colour. In ordinary mills there are only four lots, and in some two.

We have already observed, that the selection which regards the hardness of the materials is very essential; because it is of great importance to obtain stuff composed of equal parts, and without any loss. But it is necessary to add, that the fineness and beauty of the paper depend in some cases on a selection not rigorous. Thus, for example, it is of great service to allow the middle to retain some part of the fine, and the fine some part of the superfine; for without this the inferior kinds of paper can never be of great value. The most common fault is to mix the rags of the inferior lots with the superior; which, though it augments the quantity of paper, is extremely injurious to the quality. It does much better to mix part of the superior lots with the inferior. It is the want of attention to this mixture which makes some paper-mills excel in the superior sorts of paper, while the inferior kinds are of a very bad quality.

The selection of rags being made with exactness, however, and the lots being fermented and triturated separately, the mixture may be made with much greater advantage when they are both reduced to stuff: always taking care that it be in the same proportion as if it were in the state of rags, and only in the manner which we just now mentioned; for the inferior sorts gain more in beauty and quality by this mixture than is lost in stuff; whereas if the fine stuff receives a certain quantity of the inferior, the paper is more damaged in its value than increased in quantity. In this manner the interest of the manufacturer, as in all cases, is intimately connected with the goodness of his commodities.

In some mills the place for fermentation is divided into two parts, one of which serves for washing away the filth from the rags. After allowing them to steep for some time in a large stone vat, they stir them, and pour in fresh water till the impurities connected with the rags run over. When they are as clean as they possibly can be made by this kind of washing, they are laid in a heap to putrefy. In this condition they experience a degree of fermentation, which is first discovered by a mouldiness of the different pieces of cloth. Afterwards the mass grows warm; and then it is of great consequence to attend the progress of this heat, in order to moderate its effects: for this purpose, the middle of the heap, where the fermentation is strongest, is turned out, and *vice versa*. In mills where mallets are used, the putrefaction is carried to a great height, which is frequently attended with two inconveniences. The first is, that a part of the rags is reduced to an earthy substance, which is found in great abundance about the cutting-table, as we shall afterwards have occasion to see. But besides this waste, excessive fermentation makes the stuff incapable of sustaining the action of the mallets till it is equally pounded. A paper made from stuff too hard and too little fermented, is coarse and ill compacted; that made from rags too much fermented is composed of fibres without softness and without strength.

The second inconveniency is, that the rags turn greasy by too much fermentation, and of consequence it is very difficult to separate and reduce them by all the washings of the trituration.

We shall not describe the form of the

place for fermentation, because in different paper-works these places are of different constructions: it is sufficient to say, that they are all placed in low situations and made very close. The selected rags are placed in them in heaps, and watered from time to time to bring on the fermentation. In different paper-mills they practise different methods in the putrefaction of their rags.

In certain provinces in France, they lay in the place for putrefaction a heap equivalent to what the mill can triturate in a month. When this is equally and sufficiently moistened by means of moveable pipes, they cover it with an old heap, which has lain a month in a state of fermentation. When this old heap is exhausted by the mill, the new one becomes a covering to another, and so on. From this detail it is easy to perceive, that there must be near three weeks difference of putrefaction in the same heap, and also that in this method there is no allowance for those seasons in which the fermentation advances more rapidly.

In general, the putrefaction goes on more slowly in proportion to the fineness of the rags. But when, on any occasion, it advances more rapidly than the demand from the mill, the rags are turned over and watered, to stop the fermentation and prevent the bad effects.

All the inconveniences attending the excess of putrefaction are remedied in Holland by machines which triturate the rags without having recourse to it; and their success in this manner of preparing the stuff has attracted the notice of the French artist, some of whom have adopted with advantage the Dutch machinery.

Meanwhile, it is possible to carry the method of putrefaction to much greater perfection; and several manufacturers have made attempts so well concerted, as to deserve the attention of those who study the subject.

In the neighbourhood of Brussels some paper-manufacturers, who have constructed their mills after the Dutch plan, have still found it necessary to putrefy their rags; but, at the same time, they have an excellent method for moderating the effects of this putrefaction. In the great galleries connected with the buildings of the paper-mill, they have constructed a continuation of chests, capable each of them of containing a certain quantity of rags; for example, the quantity which the cylinder can triturate in one day. The number of chests is equal to the number of days which the rags in any season require for putrefaction; and the number actually employed is greater or less according to the season. In prosecuting this plan, they lay a heap of rags in one chest, as often as they take one from another. It should also be observed, that, for the sake of the fermentation, the rags are first moistened in a large hollow stone before they are arranged into the chests.

The peculiar advantages of this method are, the equal fermentation of the rags, without any part of them being weakened; great ease in washing them; and it is even pretended, that a less degree of fermentation renders the impurities and the discoloured parts both of hemp and linen more soluble, and consequently the stuff of a purer white.

When the rags are reduced to a proper state of putrefaction, they are carried to the cutting table, which is placed on solid tressels, and inclosed on three sides to contain the rags cut on it. Before the table is fixed vertically a part of the blade of a scythe, the edge of which is turned from the operator. This workman, in a situation rather elevated, takes from the left side a handful of the putrefied rags, and arranging them the long way, gives them a gentle twist, presses the half-formed rope against the blade of the scythe, and, in the manner of sawing, cuts it into three or four pieces, which he throws to the right side of the table. In this operation the rags lose part of their filth, and especially of the earthy particles occasioned by too much putrefaction.

When the rags have been submitted to all the foregoing operations, they are in a condition to be reduced into a fibrous stuff, of which the paper is made. To obtain this stuff, mills are constructed on different principles. Those which have been used for a long time over all Europe, and which by a statement in the Encyclopedie Methodique, published at Paris in 1789, are still used in France, are mills with mallets. But the mills invented by the Dutch, and used in the neighbouring provinces, and excepting one instance in every part of Great Britain, are mills with cylinders or rollers. In the former of these, the mallets are raised by notches fixed at convenient distances in a large circular beam of wood. The teeth fixed on the end of the mallet fall into a corresponding gap made the whole breadth of the plate, and the strokes are repeated till the rags are reduced to a proper consistency. In supplying the vat with water, and carrying of all the impurities, the operation is nearly similar to that in the mills with cylinders.

Such is the nature of what may be called the *old method of making paper*. It was proper to speak of this old method,

because at one time, and that not very distant, it universally prevailed. That it was inferior to that now in practice, seems very evident; and that the rotting of the rags was peculiarly absurd, cannot be denied, as the paper made of fermented stuff could neither be so strong nor so durable as that which is made in the common way without putrefaction.

The only kind of paper that with any propriety could be made from putrefied stuffs, was paste-board; but we are informed by the most intelligent paper-makers in Britain, that they seldom or never even putrefy the rags or ropes of which paste-board is made. It will now be requisite to state the method in practice at this time, with the improvements lately made in the art. And first of the duster.

The duster is made in form of a cylinder, four and a half feet in diameter, and five feet in length. It is altogether covered with a wire net, and put in motion by its connexion with some part of the machinery. A convenient quantity of the rags after the selection are enclosed in the duster, and the rapidity of its motion separates the dust from them, and forces it through the wire.

The selection is performed much in the same manner as we have already described; only it is found more convenient to have the tables for cutting off the knots and stitching, and for forming them into a proper shape, in the same place with the cutting table. The surface both of these and of the cutting table is composed of a wire net, which in every part of the operation allows the remaining dust and refuse of every kind to escape.

The rags, without any kind of putrefaction, are again carried from the cutting table back to the duster, and from thence to the engine, where, in general, they are in the space of six hours, reduced to the stuff proper for making paper. The hard and soft of the same quality are placed in different lots; but they can be reduced to stuff at the same time, provided the soft be put somewhat later into the engine.

The engine is that part of the mill which performs the whole action of reducing the rags to paste, or, as it may be termed, of trituration. The number of the engines depends on the extent of the paper-work, on the force of water, or on the construction of the machinery.

It requires great skill to conduct the engine, whether it be with regard to the first quantity, to the proper time for adding the softer rags, to the augmenting or diminishing the water in proportion to the trituration; or, finally, to knowing exactly when the stuff is reduced to a proper consistency.

In the paper manufactory at Montargis, it was attempted to introduce rollers of the greatest strength and the least weight possible, in order to give them the greater rapidity; but the experiment did not succeed: the rollers of prodigious rapidity were found to produce stuff neither in greater quantity, nor of superior quality. The most experienced artists have established a proportion between the motion of the roller and the greater or less resistance of the rags. And the Dutch, who have arrived at a very great perfection in this art, have followed a method totally different from that practised at Montargis. A roller in Holland, complete in all its parts, weighs nearly 30 hundred weight; and they find this necessary for cutting the rags, especially if they have not putrefied. In proportioning the rapidity to the resistance, they have also discovered, that a slow motion is preferable to a rapid one. The roller at Saardom, by calculation made from the different parts of the machinery, make about 68 revolutions in a minute: those at Montargis about 166. In Holland, too, this trituration of the rags is divided into two distinct operations, performed by rollers constructed on different principles: the first of them, for cutting the rags and preparing for the other, is furnished with blades of steel without any moisture, and with a considerable space between them; the second, intended to reduce the stuff to the proper consistency, has a greater number of blades, composed of a mixture of brass and copper. The mills with rollers are in every respect superior to those formerly in use with mallets. Two Dutch rollers, of the construction we have just now described, will prepare as much stuff as 24 mallets; they require infinitely less room; they do it without putrefaction; and as they do it in less time, and with less water, they occasion much less waste of the stuff.

When the stuff is brought to perfection, it is conveyed into a general repository, which supplies the vat from which the sheets of paper are formed.

This vat is made of wood, and generally about five feet in diameter, and two and a half in depth. It is kept in temperature by means of a grate introduced by a hole, and surrounded on the inside with a case of copper. For fuel to this grate, they use charcoal or wood; and, frequently, to prevent smoke, the wall of that building comes in contact with one part of

the vat, and the fire has no communication with the place where they make the paper.

Every vat is furnished on the upper part with planks, enclosed inwards, and even railed in with wood, to prevent any of the stuff from running over in the operation. Across the vat is a plank which they call the *Trapan*, pierced with holes at one of the extremities, and resting on the planks which surround the vat.

The forms or moulds are composed of wire-cloth, and a moveable frame. It is with these that they fetch up the stuff from the vat, in order to form the sheets of paper The sides of the form are made of oak, which is previously steeped in water, and otherwise prepared to prevent warping. The wire-cloth is made larger than the sheet of paper, and the excess of it on all sides is covered with a moveable frame. This frame is necessary to retain the stuff of which the paper is made on the cloth; and it must be exactly adapted to the form, otherwise the edges of the paper will be ragged and badly finished. The wire-cloth of the form is varied in proportion to the fineness of the paper and the nature of the stuff

The felts are pieces of woollen cloth spread over every sheet of paper, and upon which the sheets are laid, to detach them from the form, to prevent them from adhering together, to imbibe part of the water with which the stuff is charged, and to transmit the whole of it when placed under the action of the press. The two sides of the felt are differently raised: that of which the hair is longest is applied to the sheets which are laid down; and any alteration of this disposition will produce a change in the texture of the paper. The stuff of which the felts are made should be sufficiently strong, in order that it may be stretched exactly on the sheets without forming into folds; and, at the same time, sufficiently pliant to yield in every direction without injury to the wet paper. As the felts have to resist the reiterated efforts of the press, it appears necessary that the warp be very strong, of combed wool, and well twisted. On the other hand, as they have to imbibe a certain quantity of water and to return it, it is necessary that the woof be of carded wool, and drawn out into a slack thread. These are the utensils, together with the press, which are used in the apartment where the sheets of paper are formed.

The vat being furnished with a sufficient quantity of stuff and of water, two instruments are employed to mix them; the one of which is a simple pole, and the other a pole armed with a piece of board, rounded and full of holes. This operation is repeated as often as the stuff falls to the bottom. In the principal writing mills in England, they use for this purpose what is called a *hog*, which is a machine within the vat, that by means of a small wheel on the outside, is made to turn constantly round, and keep the stuff in perpetual motion. When the stuff and water are properly mixed, it is easy to see whether the previous operations have been complete. When the stuff floats close, and in regular flakes, it is a proof that it has been well triturated; and the parts of the rag which have escaped the rollers also appear.

After this operation, the workman takes one of the forms, furnished with its frame, by the middle of the short sides, and fixing the frame round the wire-cloth with his thumbs, he plunges it obliquely four or five inches into the vat, beginning by the long side, which is nearest to him After the immersion he raises it to a level: by these movements he fetches up on the form a sufficient quantity of stuff; and as soon as the form is raised, the water escapes through the wire cloth, and the superfluity of the stuff over the sides of the frame. The fibrous parts of the stuff arrange themselves regularly on the wire cloth of the form, not only in proportion as the water escapes, but also as the workman favours the effect by gently shaking the form. Afterwards, having placed the form on a piece of board, the workman takes off the frame or deckle, and glides his form towards the couchers; who, having previously laid his felt, places it with his left hand in an inclined situation, on a plank fixed on the edge of the nut, and full of holes. During this operation the workman applies his frame, and begins a second sheet. The coucher seizes this instant, takes with his left hand the form, now sufficiently dry, and laying the sheet of paper upon the felt, returns the form by gliding it along the trapan of the vat.

They proceed in this manner, laying alternately a sheet and a felt, till they have made six quires of paper, which is called a *post;* and this they do with such swiftness, that, in many sorts of paper, two men make upwards of 20 posts in a day. When the last sheet of the post is covered with the last felt, the workmen about the vat unite together, and submit the whole heap to the action of the press. They begin at first to press it with a middling lever, and afterwards with a lever of about fifteen feet in length. After this operation, another person separates the sheets of paper from the felts, laying them in a heap; and several of these heaps col-

lected together are again put under the press.

The stuff which forms a sheet of paper is received, as we have already said, on a form made of wire cloth, which is more or less fine in proportion to the stuff, and surrounded with a wooden frame, and supported in the middle by many cross bars of wood. In consequence of this construction, it is easy to perceive, that the sheet of paper will take and preserve the impressions of all the pieces which compose the form, and of the empty spaces between them.

The traces of the wire-cloth are evidently perceived on the side of the sheet which was attached to the form, and on the opposite side they form an assemblage of parallel and rounded risings. As in a paper which is most highly finished, the regularity of these impressions is still visible, it is evident that all the operations to which it is submitted have chiefly in view to soften these impressions without destroying them. It is of consequence, therefore, to attend to the combination of labour which operates on these impressions. The coucher, in turning the form on the felt, flattens a little the rounded eminences which are in relievo on one of the surfaces, and occasions at the same time the hollow places made by the wire-cloth to be partly filled up. Meanwhile, the effort which is made in detaching a form, produces an infinite number of small hairs in every protuberant part of the sheet.

Under the action of the press, first with the felts, and then without them, the perfecting of the grain of paper still goes on. The vestiges of the protuberances made by the wire are altogether flattened, and of consequence the hollows opposite to them disappear also; but the traces formed by the interstices of the wire, in consequence of their thickness, appear on both sides, and are rounded by the press

The risings traced on each side of the paper, and which can be discovered by the eye on that which is most highly finished, form what is called the *grain paper*. The different operations ought to soften, but not destroy it; which is effectually done by employing the hammer. This grain appears in the Dutch paper; which is a sufficient proof, that though they have brought this part of the art to the greatest perfection, they have not employed hammers, but more simple and ingenious means. The grain of paper is often disfigured by the felts when they are too much used, or when the wool does not cover the thread. In this case, when the paper is submitted to the press, it takes the additional traces of the warp and woof, and composes a surface extremely irregular.

The paper, the grain of which is highly softened, is much fitter for the purposes of writing than that which is smoothed by the hammer: on the other hand, a coarse and unequal grain very much opposes the movements of the pen; as that which is beaten renders them very uncertain The art of making paper, therefore, should consist in preserving, and at the same time in highly softening, the grain: the Dutch have carried this to the highest perfection.

The exchange succeeds the operation last described. It is conducted in a hall contiguons to the vat, supplied with several presses, and with a long table. The workman arranges on this table the paper newly fabricated into heaps; each heap containing eight or ten of these last under the press, kept separate by a woollen felt. The press is large enough to receive two of them at once, placed the one at the side of the other. When the compression is judged sufficient, the heaps of paper are carried back to the table, and the whole turned sheet by sheet, in such a manner that the surface of every sheet is exposed to a new one; and in this situation they are again brought under the press. It is in conducting these operations sometimes to four or five times, or as often as the nature of the paper requires, that the perfection of the Dutch plan consists. If the stuff be fine, or the paper slender, the exchange is less frequently repeated. In this operation it is necessary to alter the situation of the heaps, with regard to one another, every time they are put under the press; and also, as the heaps are highest toward the middle, to place small pieces of felt at the extremities, in order to bring every part of them under an equal pressure. A single man with four or five presses may exchange all the paper produced by two vats, provided the previous pressing at the vats be well performed. The work of the exchange generally lasts about two days on a given quantity of paper.

When the paper has undergone these operations, it is not only softened in the surface, but better felted, and rendered more pliant in the anterior parts of the stuff. In short, a great part of the water which it had imbibed in the operations of the vat is dissipated By the felting of paper is understood the approximation of the fibres of the stuff, and their adhering more closely together. The paper is felted in proportion as the water escapes; and this effect is produced by the management and reiterated action of the

press. Were it not for the gradual operation of the press, the paper would be porous, and composed of filaments adhering closely together. The superiority of the Dutch over the French paper depends almost entirely on this operation.

If the sheets of paper are found to adhere together, it is a proof that the business of the press has been badly conducted. To avoid this inconvenience, it is necessary to bring down the press at first gently, and by degrees with greater force, and to raise it as suddenly as possible. By this means the water, which is impelled to the sides of the heaps, and which has not escaped, turns to the centre; the sheets are equally dry, and the operation executed without difficulty.

According to the state of dryness in which the paper is found when it comes from the apartment of the vat, it is either pressed before or after the first exchange The operation of the press should be reiterated and managed with great care; otherwise in the soft state of the paper, there is a danger that its grain and transparency be totally destroyed. Another essential principle to the success of the exchange is, that the grain of the paper be originally well raised For this purpose, the wire-cloth of the Dutch forms, is composed of a rounder wire than those used in France, by which they gain the greatest degree of transparency, and are in no danger of destroying the grain. Besides this, the Dutch take care to proportion the wires, even where the forms are even to the thickness of the paper.

Almost every kind of paper is considerably improved by the exchange, and receives a degree of perfection which renders it more agreeable in the use. But it is necessary to observe at the same time, that all papers are not susceptible of this melioration; on the contrary, if the stuff be unequal, dry, or weakened by the destruction of the fine parts, it acquires nothing of that lustre and softness, and appearance of velvet, which the exchange gives to stuff properly prepared:

The sheds for drying the paper are in the neighbourhood of the paper-mill, and are furnished with a vast number of cords, on which they hang the sheets both before and after the sizing. The sheds are surrounded with moveable lattices, to admit a quantity of air sufficiently for drying the paper. The cords of the shed are stretched as much as possible; and the paper, four or five sheets of it together, is placed on them by means of a small wooden instrument in the shape of a pick-axe.

The principal difficulty in drying the paper, consists in gradually admitting the external air, and in preventing the cords from imbibing moisture. With regard to the first of these, the Dutch use very low sheds, and construct their lattices with great exactness. By this means the Dutch paper is dried equally, and is extremely supple before the sizing. They prevent the cords from imbibing the water by covering them with wax. In using such cords, the moisture does not continue in the line of contact between the paper and the cord, which prevents the sheet from stretching in that particular place by its weight, and from the folds which the moisture in the subsequent operations might occasion. The Dutch also employ cords of considerable thickness, and place fewer of them under the sheets; by which means they diminish the points of contact, and give a freer and more equal circulation to the air.

The size for paper is made of the shreds and pareings got from the tanners, curriers, and parchment makers. All the putrefied parts and the lime are carefully separated from them, and they are enclosed into a kind of basket, and let down by a rope and pulley into the cauldron. This is a late invention, and serves two valuable purposes. It makes it easy to draw out the pieces of leather when the size is extracted from them by boiling, or easy to return them into the boiler, if the operation be not complete. When the substance is sufficiently extracted, it is allowed to settle for some time; and it is twice feltered before it is put into the vessel into which they dip the paper.

Immediately before the operation, a certain quantity of allum is added to the size. The workman takes a handful of sheets, smoothed and rendered as supple as possible, in his left hand, dips them into the vessel, and holds them separate with his right, that they may equally imbibe the size. After holding them above the vessel for a short space of time, he seizes on the other side with his right hand, and again dips them into the vessel. When he has finished ten or a dozen of these handfuls, they are submitted to the action of the press. The superfluous size is carried back to the vessel by means of a small pipe. The vessel in which the paper is sized is made of copper, and furnished with a grate, to give the size, when necessary, a due temperature; and a piece of thin board or felt is placed between every handful as they are laid on the table of the press.

The Dutch are very careful, in sizing their paper, to have every sheet in the same handful of the same dryness; because it is found that the dry sheets im-

bibe the size more slowly than those which retain some degree of moisture. They begin by selecting the *packs* in the drying-house; and after having made them supple, and having destroyed the adherence between the sheets, they separate them into handfuls in proportion to the dryness, each of them containing that number which they can dip at one time. Besides this precaution, they take care to apply two sheets of brown paper of an equal size to every handful. This brown paper, firm, solid, and already sized, is of use to support the sheets.

As soon as the paper is sized, it is the practice of some paper-mills to carry it immediately to the drying-house, and hang it before it cools sheet by sheet on the cords. The paper, unless particular attention be paid to the lattices of the drying-house, is apt to dry too fast, whereby a great part of the size goes off by evaporation; or, if too slow, it falls to the ground. The Dutch drying-houses are the best to prevent these inconveniences: but the exchange after the sizing, which is generally practised in Holland, is the best remedy. They begin this operation on the handfuls of paper, either while they are still hot, or otherwise, as they find it convenient. But, after the exchange, they are careful to allow the heaps to be altogether cold before they are submitted to the press. Without this precaution, the size would be either wholly squeezed out by the press of the exchange, or the surface of the paper become very irregular. It is of consequence that the paper, still warm from the sizing, grow gradually firm, under the operation of the exchange, in proportion as it cools. By this method it receives that varnish which is afterwards brought to perfection under the press, and in which the excellency of the paper, either for writing or drawing, chiefly consists. It is in consequence of the exchanging and pressing, that the Dutch paper is soft and equal, and that the size penetrates into the body of it, and is extended equally over its surface.

The exchange, after the sizing, ought to be conducted with the greatest skill and attention, because the grain of the paper then receives impressions, which can never be eradicated. When the sized paper is also exchanged, it is possible to hang more sheets together on the cords of the drying-house. Paper dries better in this condition, and the size is preserved without any sensible waste, because the sheets of paper mutually prevent the rapid operation of the external air. And as the size has already penetrated into the paper, and is fixed on the surface, the insensible progress of a well conducted drying-house renders all the good effects more perfect in proportion as it is slowly dried.

If to these considerations be added the damage done to the paper in drying it immediately after the press of the sizing room, whether it be done in raising the hairs by separating the sheets, or in cracking the surface, it is evident that the trouble of the second exchange is infinitely overpaid by the advantage.

When the paper is sufficiently dry, it is carried to the finishing room, where it is pressed, selected, examined, folded, made up into quires, and finally into reams. It is here put twice under the press; first, when it is at its full size, and, secondly, after it is folded The principal labour of this plan consists in assorting the paper into different lots, according to its quality and faults; after which it is made up into quires. The person who does this must possess great skill, and be capable of great attention, because he acts as a check on those who separated the paper into different lots. He takes the sheets with his right hand, folds them, examines them, lays them over his left arm, till he has the number requisite for a quire, brings the sides parallel to one another, and places them in heaps under the table. An expert workman, if proper care has been taken in assorting the lots, will finish in this manner near six hundred quires in a day.

The paper is afterwards collected into reams of 20 quires each, and for the last time put under the press, where it is continued ten or twelve hours, or as long as the demand for paper at the paper-mill will permit.

A method has lately been discovered of bleaching the rags or stuff, which will undoubtedly be adopted every where, in the preparation of writing paper, provided the expense of the process be not too great. This discovery was made by Scheele, M. Berthollet, and M. Chaptal. The first of these illustrious writers, communicated to the Swedish academy of sciences, an essay on Manganese, containing a numerous series of experiments, intended to investigate the nature and properties of that substance. Among these experiments, were several which pointed out a new state of the muriatic acid, or the acid distilled, from sea-salt.

This state of the muriatic acid, was produced by M. Scheele, in consequence of putting the said acid into a retort, or distilling vessel, along with the manganese, and distilling over the acid into a

proper receiver; it was found to have changed its nature and properties, in a very remarkable manner, while at the same time the manganese remaining in the retort, had suffered a very material alteration.

To the new state of the acid thus produced, in consequence of certain theoretic ideas, which M. Scheele entertained, respecting the mutual action of the original muriatic acid, and the manganese on each other, during the process of distillation, he gave the name of *Dephlogisticated Muriatic Acid* Since the time of this original discovery, in consequence of certain changes, which had occurred, in the theory or philosophy of chemistry, this new state of the acid of sea-salt, has been called, the *Oxygenated Muriatic Acid.* Among many other properties of it, discovered by Mr Scheele, the most remarkable was, that it destroyed the colour of every vegetable substance, which was exposed to its action; or, in other words, it bleached them: or, in the language of the dyers, it discharged their colours; that is to say, whatever happened to be the colour of any vegetable body, that was submitted to the action of the above acid, it always became white, or lost its colouring matter.

In the year 1786, Dr. Bedoes, professor of chemistry, in the university of Oxford, (England) published an English translation of the Chemical Essays of Mr. Scheele; and thereby made known to the chemists of Great Britain, the power of the oxygenated muriatic acid; to bleach or whiten vegetable substances, or to discharge or decompose their colour. But M. Berthollet, a celebrated French chemist, and one of the members of the Academy of Sciences at Paris, appears to have been the first, who thought of rendering the above recited discovery, subservient to the purposes of manufacture.

In 1789, he published in the *Annales de Chimie* an essay calculated entirely, for the use of manufacturers, by being divested of theoretic discussions; of which the title is, "Method of bleaching linen or cotton cloths, threads and yarns, by means of oxygenated muriatic acid, and of some other properties, which may be useful to manufactures."

In the same work, and in the same year, M. Chaptal, another French chemist, published an account of some experiments, in which, among many other applications, of the oxygenated muriatic acid, to purposes useful in the œconomical arts, he gives information of having bleached or whitened coarse rags, used by the paper makers, so as greatly to improve the quality of the paper, into which they were afterwards manufactured His preparation of this bleaching liquor, differs not from Berthollet's, which is as follows: "Take six ounces of manganese, and 16 ounces of sea-salt, both reduced to a fine powder; mix these accurately, and introduce them into a retort or distilling vessel: then take 12 ounces of oil of vitriol, and eight ounces of water, mixed together and allowed to cool; add these to the other ingredients in the retort, and connect the retort with a cask or receiver, capable of holding 27½ gallons of water, but only containing 25 gallons, which is to be impregnated with the gas or vapour, of the oxygenated muriatic acid; and proceed to distillation, first without and afterwards with a fire gradually raised, till the whole acid comes over."

Experiments have been made with this liquor, both by some of the principal paper makers, in the neighbourhood of Edinburgh, and by Messrs Clement and George Taylors, of Maidstone in Kent. By the former it was found, that paper made of rags and pulp whitened in this manner, was superiour to any other made of similar materials, not only in colour, but in fineness of texture. By the latter, the excellence of the liquor was found to be so great, that probably having never heard of Scheele, Berthollet, and Chaptal, and conceiving themselves to be the first inventors of it, they obtained a patent for its exclusive use, which other manufacturers will doubtless disregard. It is not to be concealed, however, that even with all the precautions which can possibly be taken at first, various circumstances of imperfection, must necessarily remain to be removed, by means of farther experience, both in the perfection of the bleaching process, and the œconomy of its application to use; but for the attaining of this experience, a short time will rarely be sufficient. See Bleaching.

Section II.

Of the different kinds of Paper.

The paper proper for writing, should be without knots, without any parts of the stuff not triturated, without folds, and without wrinkles, softened in the exchange, and not destroyed by smoothing. The ground of this paper must be extremely white, or shaded with a very light blue, which adds to its natural splendor. It is of great importance that it be fully and equally sized, otherwise the writing cannot be well finished, and the turnings of the letters will be very imperfect. This paper should be made from stuff not pu-

trefied, which takes a better grain, receives more benefit from the exchange, is more equally sized, and finally, is less subject to folds and wrinkles, in the different operations. To make paper peculiarly fit for durable writing, Dr. Lewis recommends the impregnation of it with astringent materials. "It is observable (says he,) that writings first begin to fade, or change their colour, on the back of the paper, where the larger strokes have sunk in, or are visible through it; as if part of the irony matter of the vitriol, was in a more subtile or dissolved state than the rest, and sunk further, on account of its not being fully disengaged from the acid, or sufficiently combined with the astringent matter, of the galls. Hence, it should seem probable, that if the paper was impregnated with astringent matter, the colour of the ink would be more durable. To see how far this notion was well founded, I dipt some paper in an infusion of galls; and, when dry, repeated the dipping a second and third time. On the paper thus prepared, and some that was unprepared, I wrote with different inks; several of which, that the effects might be more sensible, has an over proportion of vitriol. The writings being exposed to the weather, till the best of the inks on the unprepared paper, had faded and changed their colour, those on the prepared paper, were all found to retain their blackness. It is therefore recommended to the consideration of paper makers, whether a particular kind of paper, might not be prepared for those uses, where the long duration of the writing, is of principal importance, by impregnating it with galls or other astringents, in some of the operations it passes through, before it receives the glazing; as for instance, by using an astringent infusion, instead of common water, in the last operation, when the matter is reduced into a pulp, for being formed into sheets. The brownish hue, which the paper receives from the galling, would not perhaps, be any great obstacle to its use; and, if the proposal should be thought worthy of being carried into execution, further inquiries may possibly discover the means, of obviating the imperfection, and communicating astringency without colour."

The paper used for drawing, or for coloured maps, is in some mills, made from one kind of white stuff, either fine or middling; in others from a mixture of three or four kinds of stuff, of different colours. The Dutch were not long ago almost wholly in possession of this manufacture. The same qualities are necessary in this paper, as in that for writing. The grain, however, must be a little more raised, although softened by the exchange; for, without this grain, the pencil would leave with difficulty, the traces of the objects. Great care is also necessary, in the sizing of this paper, that the drawing be neatly performed, and also that the sinking of the ink or colours, into the irregularities of the stuff be prevented.

This paper is also made in great perfection, by stuffs not rotted. These take a more even gloss, and are in better condition, to receive all the impressions of the painter. It is also necessary that furniture paper, be well softened, and submitted to the exchange, to take more exactly, the outlines of the figures. The French have carried this part of the manufacture of paper, to the highest state of perfection.

The British and Dutch, have had the greatest success in manufacturing pasteboard, which they make either from a single mass of stuff on the form, or from a collection of several sheets pasted together. In both cases, the sheets of pasteboard, are made of stuff not rotted, and triturated with rollers, furnished with blades of well tempered steel. By the operation of the exchange, and smoothing continued for a long time, the British and Dutch, obtain solid and smooth stuffs, which neither break under the folds of cloth, nor adhere to them. The stuffs not putrefied, have another advantage in this species of pasteboard, namely, that of resisting the action of heat, which they experience between the folds of cloth, without wasting or tarnishing, and of consequence they may be used for a long time.

In England they have at least equalled any other nation, in the manufacture of this paper; and even in Scotland, they have arrived to such a degree of perfection in this art, that great part of what they manufacture is sent to England. It requires to be made of a soft and equal stuff, without folds or wrinkles, of a natural whiteness, and with a shade of blue. It must be sized less strongly than writing paper, but sufficiently well to give neatness to the characters. This paper, thus properly prepared, yields easily to the printing press, and takes a sufficient quantity of ink. The stuff must be without grease, and wrought with that degree of slowness, as to make it spread equally over the form, and take a neat and regular grain; without this the characters will not be equally marked in every part of the page: and the smallest quantity of grease

renders the sizing, unequal and imperfect. Some artists with considerable success, both to meliorate the grain, and to reduce the inequalities of the surface, have submitted this paper to the exchange. And it is proper to add, that a moderate degree of exchanging, and of pressing, may be of great service, after the sheets are printed, to destroy the hollow places occasioned by the press, and the relievo of the letters

Engraving requires a paper of the same qualites, with the last mentioned, with respect to the stuff, which must be pure without knots, and equally reduced; the grain uniform, and the sheets without folds or wrinkles. To preserve the grain, it is necessary that it be dried slowly, in the lowest place of the drying-house. If it is submitted to the exchange, the effects of it must be moderated with the greatest care, and the action of the two first presses, must be equally distributed over the whole mass, otherwise the inequality of the moisture at the middle and sides, will expose it to the wrinkles in the drying. The sizing of this paper, must also be moderate. These circumstances, are necessary to make it receive with neatness, all the soft and delicate touches of the plate. The soft and yielding paper of Auvergne, possesses all those advantages; and accordingly, a great quantity of this, and of printing paper, were formerly imported into Britain and Holland from France, where they still continue to rot the material, from which they make engraving paper. The wire wove frame, though but lately invented, is, we are told, peculiarly adapted to this kind of paper.

Paper for cards must be manufactured from a pretty firm stuff, in order to take that degree of smoothness, which makes the cards, glide easily over one another in using For this reason the cardmakers, reject every kind of paper which is soft, and without strength. This paper requires to be very much sized, since the sizing holds the place of varnish, to which the smoothing, gives a glazed and shining surface. To answer all these purposes, the rags require to be a little rotted, and the mallets strongly armed with iron studs. At present, Angoumois is almost the only province in France, which sells card-paper to the Dutch, and the other northern nations. The rags of Angoumois, have the peculiar quality of not turning too soft, in the putrefaction, and the mills of that province reduce them to stuff, though they be not much putrefied. The French, we believe, excel every other nation, in this branch of the manufacture of paper.

Section III.

Misellaneous Observations on Paper.

To hinder paper from sinking, take about the size of a nut of rock alum, dissolve it in a glass of clear water, and apply it to the paper, which has not been sufficiently sized, with a fine sponge It is in this manner, that the paper manufacturers of Paris, prepare the paper for drawing, called *papiers laves.* When there is occasion to write on a printed book, or on paper too fresh, it is sufficient to mix a little gum with ordinary ink.

To give to writing paper a brilliant varnish, take that which is of an ordinary fineness, very smooth, without any kind of stain or hairs on its surface; stretch it on a smooth plank, and by means of a hare's foot cover it with a thin and equal layer of sandarac finely powdered. Afterwards, if a whole ream is to be varnished, take eight ounces of rock alum and one ounce of white sugar-candy; bring them to boil in six pints of water; and when the liquor is lukewarm, wet that side of the sheet which has been covered with the sandarac with a fine sponge; lay the sheets in a heap, one sheet exactly above another; and submit the ream to the press for the space of twelve hours: hang them afterwards, sheet by sheet, on the cords of the drying house; put them again under the press for some days to stretch them; and finally, beat them with a bookbinder's mallet. This paper can only be used for three or four months after it is prepared.

Painters prepare their paper for drawing, and give it a dark ground, which spares them much labour of the pencil afterwards in those places where shade is necessary. For this purpose, they take white paper and pass a sponge over it, which has imbibed water impregnated with soot, leaving the light places to be formed afterwards. They use also a kind of paper for drawing, which is called tainted paper. A light colour is passed over the whole ground, which deprives the paper of its original brightness, and makes the light places of the print appear more in relievo, and more luminous.

The method most common and most convenient for copying a print, is to use oiled paper. The manner of preparing this paper is to take that which is thin and smooth, known commonly by the name of *serpent paper*, and moisten it with a composition, of two parts of the oil of walnuts, and one part of the oil of turpentine, mixed well together. A sheet of pasteboard and a sheet of paper are laid on a smooth table; above them are placed

two sheets of paper to be prepared; and a layer of the oil applied to the uppermost is sufficient to penetrate both. This may be done to any number of sheets, and a strong sheet of prsteboard is placed over the whole. The heap is afterwards submitted to the press, under which it remains for two or three days, till the oil be completely dry. Paper prepared in this manner serves to copy very readily and exactly all kinds of figures and plans; because, being altogether transparent, all the parts of the drawing, whether of light or shade, are easily distinguished.

Besides the paper made from the asbestos, it is necessary for wrapping up gunpowder and valuable writings, to have a paper that will not easily take fire. The manner in which this is prepared is extremely simple. Ordinary paper is dipped into boiling liquid, consisting of three-fourths of water, and one-fourth of dissolved alum. This salt, which is not inflammable, covers the surface of the paper, and renders it in some measure incombustible.

In the season of verjuice, a little of it diluted with water is sufficient for obliterating any fresh spot of ink. The salt of the verjuice, dissolved in water, answers the purpose equally well; and the salt of the sorrel is also employed, thongh with less effect. If the spots be dry, and the above acids are insufficient to eradicate them, a little aquafortis diluted in water, and applied with the feather of a quill or a fine hair-pencil, will make them entirely disappear.

Books and manuscripts are sometimes defaced by accidental stains with oil. To remove such blemishes, burn sheeps' bones, and reduce them to a fine powder; lay a quantity of this powder on each side of the stain; place it between two sheets of white paper, and submit it for twelve hours to the press. If the stains have not disappeared, it will be necessary to reiterate the process.

To make oiled papers take colours; mix with the colours a very small quantity either of the gall of the pike or carp; and as these substances are of the nature of soap, they dissolve the grease that is in the paper, and permit the colours to be spread over the surface.

Emery paper, which is employed for taking the rust from iron without wasting it, is made by impregnating coarse paper with gummed water or any other tenacious substance, and then covering it over with the finest emery.

The colours proper for paper are not different from those used for other substances, and are enumerated under the article *Colour-making* They are applied with soft brushes, after being tempered to a due degree with size, or gum water. If the paper on which they are to be laid is soft, so that the colours are apt to go through, it must also be sized before they are laid on, or a proportionably larger quantity must be used along with the colours themselves. If a considerable extent of paper is to be done over with one colour, it must receive several coatings, as thin as possible, letting each coat dry before another is put on, otherwise the colour will be unequal.

To gild paper.

Take yellow ochre, grind it with rain-water, and lay a ground with it upon the paper all over; when dry, take the white of eggs, beat it clear with white sugar candy, and strike it all over: then lay on the leaf gold, and, when dry, polish it with a tooth. Some take saffron, boil it in water, and dissolve a little gum with it; this they strike over the paper, lay on the gold, and, when dry, they polish it.

To silver paper after the Chinese method, without silver.

Take two scruples of clear glue made of neats' leather, one scruple of white alum, and half a pint of clear water; simmer the whole over a slow fire till the water is consumed, or the steam ceases: then, your sheets of paper being laid on a smooth table, you dip a pretty large pencil into the glue, and daub it over as even as you can, repeating this two or three times: then sift the powder of *talc* through a fine sieve, made of horse-hair or gauze, over it; and then hang it up to dry: when dry, rub off the superfluous *talc*, which serves again for the same purpose. The *talc* you prepare in the following manner: Take fine white transparent Muscovy talc; boil it in clear water for four hours; then take it off the fire, and let it stand so for two days: then take it out, wash it well, and put it into a linen rag, and beat it to pieces with a mallet: To 10 lbs. of talc add 3 lbs. of white alum, and grind them together in a little hand mill; sift it through a gauze sieve; and being thus reduced to a powder, put it into water, and just boil it up: then let it sink to the bottom, pour off the water, place the powder in the sun to dry, and it will become of a hard consistence. This beat in a mortar to an impalpable powder, and keep it for the use above mentioned, free from dust.

White and coloured grounds for Paper-hangings.

The common grounds laid in water are made by mixing whiteing with the common glovers' size, and laying it on the paper with a proper brush, in the most even manner. This is all that is required where the ground is to be left white; and the paper being then hung on a proper frame till it be dry, is fit to be printed. When coloured grounds are required, the same method must be pursued, and the ground of whiting first laid on; except in pale colours, such as straw colours, or pink, where a second coating may sometimes be spared, by mixing some strong colour with the whiting.

Method of painting Paper-hangings.

There are three methods by which paper-hangings are painted. First, by *printing* on the colours; the second, by using the *stencil;* and the third, by laying them on with a *pencil,* as in other kinds of painting.

When the colours are laid on by printing, the impression is made by wooden prints, which are cut in such manner that the figure to be expressed is made to project on the surface, by cutting away all the other part; and this being charged with the proper colours, tempered with their proper vehicle, by letting it gently down on a block, on which the colour is previously spread, conveys it from thence to the ground of the paper, on which it is made to fall more forcibly by means of its weight, and the effort of the arm of the person who uses the print. It is easy, he concludes, that there must be as many separate prints as there are colours to be printed. But where there are more than one, great care must be taken, after the first, to let the print fall exactly on the same part of the paper as that which went before; otherwise the figure of the design would be brought into irregularity and confusion. In common paper of low price, it is usual, therefore, to print only the outlines, and lay on the rest of the colours by stencilling; which both saves the expense of cutting more prints, and can be practised by common workmen, not requiring the great care and dexterity necessary to the using several prints.

The manner of *stencilling* the colours is this. The figure, which all the parts of any particular colour make in the design to be painted, is to be cut out, in a piece of thin leather, or oil-cloth, which pieces of leather or oil-cloth are called stencils; and being laid flat on the sheets of paper to be printed, spread on a table or floor, are to be rubbed over with the colour, properly tempered, by means of a large brush. The colour passing over the whole is consequently spread on those parts of the paper where the cloth or leather is cut away, and gives the same effect as if laid on by a print. This is, nevertheless, only practicable in parts where there are only detached masses or spots of colours; for where there are small continued lines, or parts that run one into another, it is difficult to preserve the connection or continuity of the parts of the cloth, or to keep the smaller corners close down to the paper; and therefore, in such cases, prints are preferable. Stencilling is indeed a cheaper method of ridding coarse work than printing; but without such extraordinary attention and trouble as render it equally difficult with printing, it is far less beautiful and exact in the effect. For the outline of the spots of colour want that sharpness and regularity that are given by prints, beside the frequent extra-lineations, or deviations from the just figure, which happens by the original misplacing of the stencils, or the shifting of the place of them during the operation.

Pencilling is only used in the case of nicer work, such as the better imitations of the India paper. It is performed in the same manner as other paintings in water or varnish. It is sometimes used only to fill outlines already formed by printing, where the piece of the colour, or the exactness of the manner in which it is required, to be laid on, render the stencilling it or printing it less proper; at other times, it is used for performing or delineating some parts of the design, where a spirit of freedom and variety, not to be had in printed outlines, are desired to be had in the work.

Management of the Flock paper.

The paper designed for receiving the flock is first prepared with a varnish-ground with some proper colour, or by that of the paper itself. It is frequently practised to print some Mosaic, or other small running figure in colours, on the ground, before the flock be laid on; and it may be done with any pigment of the colour desired, tempered with varnish, and laid on by a print cut corresponding to that end.

The method of laying on the flock is this: A wooden print being cut as is above described, for laying on the colour in such manner that the part of the design which is intended for the flock may project beyond the rest of the surface, the varnish is put on a block covered with leather or oil-cloth, and the print is to be used also

in the same manner to lay the varnish on all the parts where the flock is to be fixed. The sheet, thus prepared by the varnished impression, is then to be removed to another block or table, and to be strewed over with flock, which is afterwards to be gently compressed by a board, or some other flat body, to make the varnish take the better hold of it, and then the sheet is to be hung on a frame till the varnish be perfectly dry; at which time the superfluous part of the flock is to be brushed off by a soft camel's-hair brush, and the proper flock will be found to adhere in a very strong manner.

The method of preparing the flock is, by cutting woollen rags or pieces of cloth with the hand, by means of a large bill or chopping-knife, or by means of a machine worked by a horse-mill.

There is a kind of counterfeit flock-paper, which, when well managed, has very much the same effect to the eye as the real, though done with less expense. The manner of making this sort is, by laying a ground of varnish on the paper; and having afterwards printed the design of the flock in varnish, in the same manner as for the true, instead of the flock, some pigment, or dry colour, of the same hue with the flock required by the design, but somewhat of a darker shade, being well powdered, is strewed on the printed varnish, and produces nearly the same appearance.

An account of the mode of making Paper, practised in the United States.

What we have just given in this article has been extracted from the several accounts of the business as it has been practised in Europe, under various circumstances, in the different countries; but as most of our arts here, have the advantage of the experience and emigration of all the foreigners, the several different modes of work have been brought over, and the practice we have adopted seems to have arisen out of a fair comparison of them all. We are also authorized to state, that from the advancement of the art here, the machinery and proficiency of workmanship of the best mills, has been introduced very perfectly, though not to so great an extent as it exists in several manufactories in England. We shall, therefore, now add a brief description of the business in all its several stages, and connect with it some remarks on the most obvious advantages for its improvement.

On Paper-mills and Machinery.

In the erection of paper mills, it is of the greatest advantage to obtain a large level ground near the moving water-power, and to make use of it to dispose of the various branches of the business as separate as possible. The mill, consisting properly only of that part connected with the grinding of the rags, and the machinery attached thereto, till it is pressed out into wet sheets of paper; thus, therefore, a building for this purpose, in a good mill, ought to be made separate, undetached from any other: into this the rags are brought from the rag-house, hereafter described, and from this the sheets of paper are taken, after formation, for drying, finishing, &c. into the work-house, and, for the subsequent processes.

On one side of this middle building, called the mill, ought to be erected a rag-house, into which the rags are to be received, weighed, and kept in bulk; in part of this also they are to be assorted, and afterwards dressed on the screens. No communication ought to be had from this building to the mill, except by the foreman of the rag-house, or engineer, when the regular day's work of rags are taken into the mill for the purposes of being made into paper

On the other side should be the general work-house of the mill, consisting below of a room to receive the paper wet from the vats, each morning, after pressing during the preceding night; which room is to be furnished with presses for pressing in the more advanced state of the process, and with benches to assort and part the packs on, and here it receives the complete process of parting and pressing until it is taken up in the loft to dry. Near or adjoining this room, should be the sizing-house, and by this convenience being at hand, the sized paper can be brought to be parted after it is sized, as it is so done, in the same manner as the wet paper, after which it also is taken into the loft to dry.

Connected with the sizing room ought always to be built the kettles, hung in an elevated situation for boiling the size, and also for hot water, so that the size can at all times be run off into the sizing room, and without the dirt or incumbrance of the fire, or even the free passage of air, which ought to be excluded.

On the ground near this end or side of the groupe of buildings, ought also to be the hardening room, used for hardening the sized paper in damp seasons, and for keeping paper generally when ready to leave the mill.

Above the work-house, if not convenient on the same floor, is the great finish-

ing room, called the salle, with benches for picking, sorting and finishing the paper, and arranged round it, are the presses for pressing the paper when dry, after being sized, or for finishing those papers when dry, which do not require sizing.

Above this building or the before mentioned rooms, is the drying loft, into which the paper is received after being pressed and parted when from the vats, or after being separated from the size; and in general also to hang and dry the paper under any circumstances. This room ought to be opened to the roof of the house, in order to afford as much airing as possible.

The advantages of this arrangement are very great, as it preserves the stock of rags, in which there is always much dust, from the paper, pulp, &c. which it is indispensible to preserve in the utmost degree of cleanness. It separates also that part of the business where, if there is any risque of fire owing to the dryness of the paper, and from the mill, machinery, and rags; and also, as in this business there is a greater difierence in the various stages of manufacture than in any other, from taking a foul material and producing a most beautiful article of distinguished cleanness, so there is an especial difference in the hands to be employed, and consequently in their government. So much for general outline, we shall now briefly go through the description of the interior, and at the same time, the process of the business.

The Rag-house.

Into this building the rags are first brought, and it is better to put them into the upper story, to which they may be hoisted; in this have binns to hold quantities in bulk as received, and also binns to hold the separate kinds as they are sorted.

At one end of this story, should be a closed room for sorting the rags in winter, and which must be warmed for the people: in this room, must be placed several long rag screens or frames of wood, with the open part covered with wire, and having in the middle, a rag knife fixed upright; the rags are brought from the heap as received, and thrown over them, and here they are assorted, into the different qualities, ready to go into the binns; when rags come, as they often do, two kinds sowed together, they are separated by drawing across the knife, and each quality, is thrown into a separate heap. The first are fine white rags, linen, or cotton; the second, coarser in texture, and the third, hard rags, generally linen, or low, cotton; fourth, inferior, of the same description; then comes the colours, corduroys and other sorts, generally, as the mill is to be employed the kinds are adapted thereto.

It often happens, that when a particular branch of work is chosen for a mill, the rags suitable for it are sorted out, and the inferior ones, sold to much greater advantage, than manufacturing them, and the mill at the same time is working, at its particular line, at a saving of implements, which cannot readily be used, in both the fine and coarse branches.

When the rags are sorted in this manner, they are ready for use, and when fine, seconds, or other qualities are to be used, a quantity of them are taken into the lower room, which is called the rag dressing room, this room is furnished with a rag screen, with a knife fixed in it, for each person and it ought to be placed with the left hand against a window, and a lage box at the right hand, divided into three parts. The screens are placed on one side of the room, along the row of windows, with a passage for the rag dresser between each: here the rags are brought down, and cut ready for the engineer, into small pieces, and all the seams opened, all dust and dirt carefully taken out, and they are occasionally rubbed hard over the wire, so as to shake off all the lint. Now as the sorting of the rags, in the upper room is never very perfect, here this is corrected, and the rags are ready for use.

The engineer then takes them from the sorter, and looks them over, on a larger screen, and after finding them well done, puts them into the duster, which is a rolling screen, moved by the machinery of the mill; and situate either in the mill or in the rag-house, as before mentioned; in this they are revolved about half an hour, and the dust and lint much shaken out; after this the engineer looks them over again, and prepares them for the engine; they are then taken into the mill.

The Mill.

A good mill for fine work, ought to have two sorts of engines; the one for *washing*, the other for *beating*.

A washing engine as now used, is formed of a chest about 9 feet long, by 4 feet wide, and one foot ten inches deep; the beating engine is rather shallower, and about 11½ feet long; in each of them is fixed a cylinder, on one side extending half the breadth of the engine, and which cylinder called the role, contains, for the washing engine, 36 thick bars, set at equal distances round it, and extending

out about two inches, works over a plate containing about eight bars, screwed tight together, and fixed firmly into the bed of the engine, at the bottom, but in which the circle of the role runs. The role of the beater is much the same, but contains 48 thinner bars; moving over a plate, which has from 8 to 15 bars, the latter in fine mills, are formed of steel saw blades, separated by thicker bars of copper, and laid at a small angle with the bars of the role; the stuff obtains a circular revolution round the engine, from the motion of the role, and becomes ground or beaten, as it is termed, by successively passing, between the revolving role and the plate; the role being covered with a box, called the cub, in which there are two strainers of wire, and the water is discharged by pipes behind them, as the mass of water and rags is thrown against them, by the role, when revolving in its process of grinding.

As soon as the engine is to be used, it is filled with water to near the top, and the charge of rags, which is 100 pounds, prepared and brought into the mill, is put in by handfuls into the washing engine, in which the role is kept revolving, drawing them under it. After the rags are put in, and become well wet, the washing role is lowered upon the plate for sometime, in order to break them open, and it is then kept running upon them, more like bruising them than grinding, for five or six hours; if coarse rags, longer, or fine tender rags a shorter time; in this process, a large quantity of water is kept passing, both in and out of the engine, as it is the chief object of the engineer, to admit a very large quantity of water, to go through the rags, and in order to do this, the bars of the role are always blunter, than is necessary for beating. Herein is the advantage of a washing engine, the revolution is also made much slower, by having a larger trundle head, if on the same wheel with the beating engine, and it never exceeds 120 turns per minute. When the rags are washed, they are let through a valve, which is opened in the bottom of the washing engine, into the beating engine, where they are washed for a short time, to remove any dirt which may have collected in the pipes, and after this they are regularly beaten for the pulp, which takes a process of about six hours longer, or shorter, according to the hardness or tenderness of the rags; the revolutions of this role, are from 120 to 160 times in a minute, these being the slowest and greatest speed.

The management of the beating engine, is of the highest importance to the fabric of the paper, and must always be carefully attended to; the different effects are produced by two methods, diminishing the speed of the role, and by lowering, or raising it from the plate. The best stuff is made, when the rags are hard and firm, and when the motion of the role is kept pretty swift, gradually lowered on the plate.

If any colouring of blue or other matter, is to be introduced into the paper, it is done when first put into the beater: this is generally done in fine papers; blue either of indigo, as used in blueing clothes, or a solution of that article, in sulphuric acid, strewed in small quantities, called by druggists, Saxon blue; or the fine cobalt blue, called smaltz, are used; the two former being soluble in water, dye the paper, the latter being insoluble, is intimately mixed through it, and colours it in mass; the proportions of each of these, is according to the colour required, and in this the artist must be governed by experience, as it differs in thick and thin, and in fact in all kinds of paper.

Paper is often (of the lower qualities,) sized in the engine, principally printing paper, which saves much expense, and the trouble of the future process, of sizing it with glue; it is done by strewing into the engine while beating, and immediately after the washing is completed, about one pound of fine powdered alum, and a gill of cold drawn linseed oil.

The greatest care ought to be taken, not to suffer any specks, dirt or iron mould, to get into the paper, for this purpose all the implements of bowls &c. used, ought to be of copper, and all the conveying pipes lead; at each engine there is also a water box for rincing it, and no stuff ought to be permitted to remain, attached to any part, as in a single instance, it ruins a whole engine of rags, by coming off unbeaten, and mixing in this state with the mass, forms afterwards knots and lumps, which are ruinous to the workmanship of the paper, causing holes and other evils, in the after operation.

When the stuff becomes beaten, it is discovered by repeated trials, in a bowl of water, and by experience; it is however observable, that the best paper is made, when the stuff is polished, by long beating in the engine, with a plate moderately dull, as the principal is not to grind or mince the stuff finer in proportion, than it ought to be, for the fineness of the paper; if it is, the paper is always tender in its manufacture; a loss arises in quality from being broken in its subsequent stages, and also in its use.

After the stuff is sufficiently beaten, it

is let down by a valve, through a pipe into a stuff chest, or reservoir, which ought to be a long deep square box capable of containing about four engines, and to have a small box of clear water to wash any stuff which may adhere to its sides; in this the stuff collects, and is drawn off for use by another valve, whence it descends through a pipe to a serving chest at the vat. If the stuff chest contains four engines, it is about right, as it will keep a supply, in case of any accident to the machinery, and by these means stuff may be got a-head, which is occasionally a relief to the engineer; but four engines is capacity enough, as more stuff sometimes becomes thick, or injures by the water standing too long in hot weather.

The vat is a square box of about six feet each way at the top, sloping to about four feet at bottom, about three and a half feet deep; one side or back is perpendicular, and through this is inserted the copper pot, having in it a grate and a fire to warm the vat; and from the pot a pipe or elbow is taken out in the vat, which draws the fire through the pot, and heats the vat much better; the smoke from thence passes into a chimney; and the vat ought to be so constructed at the side of the room, that the fire place may always be on the outside of the house. The vat pot must always be so set in the vat, as to be covered with water.

The vat man, in commencing work, fills the vat with water from the spring pipe, which ought always to be at the side of the vat, and with the stuff from the stuff chest at the same time, and mixes it thick or thin according to the sort he means to make from the stuff; it is always delivered to the vat at the right hand side of the workman, and he regulates his work by having drawn the stuff into the small box or sewer attached to the side of the vat, and also at the end of the pipe from the stuff chest, there being again a valve from the feeding box into the pipe which leads thence to the vat: this answers as a guage for the future supply of the stuff.

The vat being supplied, is kept heated by the pot to about 160°, say for all fine papers. The vat-man then commences his work.—He then stands at the breast of the vat, and dips into it the mould. The mould is of a frame of wood formed with bars, and on it is placed wires, either fastened in bars, or wove finer or coarser according to the work. When the mould is of bar wire, the coarsest has about twenty wires, with a space about equal to their thickness in an inch. When wove, the wires are of meshes from 25 to 60 to an inch. The mould is surrounded by a moveable frame called a dickle, which is put on when the mould is dipped in, and secures the stuff on the mould, then it is taken off, and in turn put on the other mould. The workman dips the mould into the vat, after taking it in his two hands each about the middle of the two ends, and pressing down the deckle with his two thumbs; by sinking down the side of the mould which is next him nearly perpendicular into the stuff about half way of the mould, and then gently bringing it up level with the stuff on its surface. As soon as it is out of the water the stuff begins to sink by the water passing through the wires; but he takes this instant, in which it poises, to gently throw off some of the water over the opposite side of the mould, as it will run that way after his bringing it up from the vat; and in the process of forming the sheet, he shakes it in a similar manner to a person sifting cinders.

The sheet, if well formed, will at once have a level polished surface, free from rash or frayed stuff, and care must be taken not to let any drops get into the sheet from the dickle; the stuff, if properly beat in the engine, will work, as the workmen call it, *wet*, that is, stay a longer time on the mould; but if ground fine, will sink almost at once, and when this is the case, it will never make good paper.

The stuff in the vat, particularly if smaltz be used, must be frequently stirred, or have a *hog*, which is a machine turned by a stream of water on a small water-wheel outside the vat, and unites by a water-tight brass collar, with a set of flyers inside the vat, almost like the flyers in a wheat fan. It is a machine now in universal use in a fine vat. A dash like that for a churn is also occasionally used, to keep the stuff evenly suspended, or the workman will have too much trouble to form his sheets as even as they ought to be.

The vats ought always to be situated in rooms or offsets of the mill, and lighted well, kept close to themselves; sky-lights are always best.

The vat-man having formed the sheet of paper, passes it to the coucher over a small vat-bridge at the left hand corner of the vat, and the coucher receives it with his left hand, and rests one side of it in a notched piece of wood called a jack, where it drains; the coucher having previously pushed a mould, from which he had just taken the newly formed sheet, along the middle of the vat on the vat-

bridge, for the vat-man to receive for the next sheet.

The coucher, having laid the felt over the sheet of paper he had last couched, takes the mould from the jack with his left hand, brings it round into his right, with which he reverses the mould by resting the side against the right hand side of the post of felts; then reverses his hands by putting his left hand to the top or side, and his right hand to the side of the mould, which touches the felt, and turns it over, gently pressing the same on the felt; the sheet will then be left on the felt, and, if well done, very perfect; but subject, as well as in making, to various accidents, which are named and well known by the technical names of the trade, and which the workman only can correct.

The coucher lays alternately a sheet of paper and a felt; but the nap sides of the felts must always be uppermost, as the paper sticks to it. When 125 sheets, or 5 quires, are made, the felts are all used, and the pack or post put under the press, which is filled up to the screw, with the head blocks, and the engineer, loft's-man, vat-man, and others, press it with a lever of about 17 feet long, to squeeze it as dry as possible, the paper thence obtains its consistency and firmness The press is then stricken off, and the pack is drawn through to the opposite side of the press, where the lay boy takes the paper off from between the felts, throwing each felt on a board or bench, which is fixed in the press for the purpose, and from which the felts are taken again, and used by the coucher in his subsequent post.

The packs collected during the day are usually pressed in the vat press after the work is done, and left to stand till next morning, to acquire a grain, previous to being taken the next day into the workhouse.

The felts for couching are made of thick, open wove, woollen cloth, generally twilled, and are desirable to be very spongy, and thicker or thinner according to the heaviness of the sheet and size of the paper. Post felting is necessary to be the finest and thinest, as it is the thinest paper made, and the large thick paper must have thick felting, in order to absorb the water, which would otherwise cause the paper to slip in the couching, or run from the sheet before pressing, which would be very injurious to it. A felting is therefore made on purpose for papers of each sort, and not fulled, but sheared on one side, the paper always adhering to the nap, which is the side kept up, and on which the paper is laid.

As soon as the paper is taken from the felts by the lay-boy, some of the sheets are to be dried, in order to try its weight, which is very material, and if too heavy or too light, the vat-man is instructed to correct it.

The number of posts made per day is regulated by the day's work agreed to be made for each sort of paper; which varies on each size, the smaller sizes having the greater quantity for a day's work, and of these the foolscap, pot, and in some instances the demy, are made two sheets on each mould, the sheets being divided by a transverse bar, separate on the mould, and are taken up from the felt.

The accustomed day's work in America is much less than in England; they are exhibited in the following table, and, as this place affords us the best opportunity, we shall here give a complete list of the names, sizes, and weights of all the papers usually made; observing, however, that variations continually take place, for particular orders, not in the usual line of business.

Statement of the Weights, Sizes, and Day's work of Paper manufactured in the United States and in England: obtained for the Paper maker's Society, and presented per report Jauuary 1812.

Denomination.	ENGLAND.				UNITED STATES.				
	Size in inches.		Weight.	Day's work in reams per day.	Size in inches.		Weight.	Day's work in reams per day.	
Atlas double	55 by	31 1-2	236						
Atlas	26 1-4	34	98	2½	26 by	34	90	2	
Inferior	26 1-4	34	96	2½					
Small	25	31							
Columbia	23 1-2	34 1-2	100	2½	23 1-2	34 1-2	90	1	Drawing
Copy writing	16	20 1-4	17	9					
Crown single	15	20	15	10	14 1-4	18 1-4	18		
Inferior	15	20	15	10	14 1-4	18 1-4			
Double	30	20	24	5					
Inferior	30	20	23	5					
Tissue	15	20	5						
Cartridge square	24 1-4	25 1-2	56	5					
Cartridge	21	26	56	5					
Do. Royal	19 1-4	24	50	5	19 1-4	24	26		
Copy plate	16	20 1-4	25	9					
Crown plate	15	20	22	10	14 1-4	18 1-4	23	5½	Music
Demy single	17 1-2	22	20½	7	17 1-4	21 1-4	16	6	
Inferior			38	7					
Plate			30	6					
Plate	15 1-2	20	26	6					
Short	14	20 1-4	25	9					
Tissue	17 1-2	22	7	7					
Writing	15 1-2	20	24	6	15 3-4	20 1-4	24	4½	
Large double	28	40	60	3					
Double	36	38 1-2	50	3½					
Elephant	23	28	40	4½					
Common	23	28	38	4½					
Fan, large	23 1-2	20 1-2	91						
Small	22 1-2	13 1-2	8						
Foolscap, Spanish / American	13 1-2	16 3-4	15	10	13 1-4	16 1-2	14	8	
Second	13 1-2	16 3-4	15	10	13 1-4	16 1-2	12	8	
Eagle, American					24	39	110	1	
Grand	26 3-4	40	120						
Imperial, Writing	22	30 1-4	80	3	22	30 1-4	75	2	
Plate	22	30 1-4	80	3	22	30 1-4			
Littress	13 1-2	17 1-2	17	10	14	16 1-2	15	8	
Medium, Writing	17 1-2	22 1-2	34	5½	17 3-4	22 1-2			
Printing	18	23	22	6½	18	23	20	5½	
Post, Thick large	16 1-2	21	21	6	16 3-4	21 1-4			
Thin large	16 1-2	21	16	6½	16 1-2	21 1-4			
Thick	15 1-4	19 1-2	13	6½					
Thin	15 1-4	19 1-2	18	7					
Extra thin	15 1-4	19 1-2	8						
Small	13 1-2	16 1-2	10	10	12 1-2	15 1-2	10		
Pott, Fine	12 1-2	15 1-2	10	12					
Second	12 1-2	15 1-2	9	12					
Double	17	25 1-2	18	6					
Royal, Writing	19 1-4	24	45	6	19 1-8	24		3½	
Plate	19 1-4	24	46	5					

Denomination.	ENGLAND. Size in inches.		Weight.	Day's work in reams per day.	UNITED STATES. Size in inches.		Weight.	Day's work in reams per day.
Royal, Long -	18	27 1-2	45	5				
Printing -	19 1-4	24	28	6	19 1-8	24	22	5
Inferior - -	19 1-4	24	25	6	19 1-8	24	20	5
Superroyal, Writing	19 1-4	27 1-2	54	4	19 1-2	27		
American, *newspapers*,					21 1-4	27 1-2		
Blue Demy -	17 1-2	22	18	7				
Platting - -	17 1-2	12	18	7				
Blue Elephant -	23	28		4½				
Crown, Blue & single	15	20	14	10				
Blue Royal -	19 1-2	24 1-4	25	6				
Blue couples	12	10	20	10				
Or -	9	7 1-2	20	10				
Double 2 pound	24	16	18	4½				
2 pound single	16	11	9	9				
Lumber hand -	23	18	19	7				
Middle hand -	22	16	16					
Purple royal -	19 1-2	24 1-4	26	6				
Royal hand, thick	24	19 1-2						
Hand - -	24	19 1-4	22½	6				
Small hand -	19 3-4	16	12	10				
Double -	32	20	24	5				
Sugar blue -	21	23	150					
Smaller size -	18 3-4	27	112					
Demy size -	17 1-2	22	70	6				
Crown size -	15	20	50	6				
Blue crown, Double	20	30	24	5				
Middle hand do.	31	21	30					
Bag cap -	23 1-2	19	50	6				
Four pound -	20	16	40	9				
Double four pound	33	20	80	4½				
Pound and half	12	10	24	10				
Pound couples -	9	7 1-2	24	10				
Harm cap -	24	10	56	6				
Imperial cap -	29	22	90	4½				
Kentish cap -	21	18	36	7				
Small cap - -	20	15	16	12				
Single 2 brown	16	11	15	10				

Before leaving the stage of the business last described, we shall mention some matters which refer to the previous parts of the subject.

The description of the mill now given is not only the most approved for practice, but every other plan of mills must gradually go out of use, together with machinery, &c. as the true interest of the business is attended to: thus of the mortars first introduced here, we believe none remain; the cylinders answering every purpose of good manufacture, and vastly more expeditious and preferable in every respect. The mortars, it is true, made very excellent tough paper, but very slow, and were used before the demand was great, or the art of managing cylinders was known. Copperplate papers were made very well with them, where the sheet was not required to be fine, clear, and even, and where the texture was desired to be open, not close and firm. They were first introduced here by the Germans.

The fermentation never has been adopted or even known here; it is certainly injurious to the character of the manufactory, that the idea of its being necessary should obtain, as it is contrary to the whole economy of the art. The principle of forming paper stuff is not to rot or

destroy the material, but carefully to cleanse it from all extraneus matters, to take the sound good rags, which alone can make a valuable article, and by washing and beating them, to dissolve, and afterwards re-arrange them, by a course of workmanship, so that the fibres of the rags are, under a good vat-man, matted together by his work on the mould, with the same art and dexterity that the fur is formed into the felt of hats.

Throughout the process of forming the paper in the mill, as we have observed, the utmost care must be paid to cleanliness. For this purpose, the finest spring water is obtained, and a settling pond, or where the situation of the mill admits of it, often a handsome fountain is erected, where it is collected and pumped up, for the engine vats, &c. and it undergoes various exposures for settling and filtration, before it is used; the water course of the creek being only used to turn the water power, or machinery of the mill.

We have stated also in this account the various machinery, so situated as to run throughout, from one engine to another, and to the stuff chest and vat by pipes and valves, which is by far the best method, and ought always to be accomplished if possible, and may be done by having the gearing elevated by vertical machinery. It is also of great consequence to have all the different receptacles of the stuff coated with lead; engines, stuff chests, vats, &c. and all the pipes of lead, and the valves of brass or copper.

Having now described the machinery and process, so far as to produce paper in water leaf, or its first formation, ready for the workhouse, we shall proceed to the further branch of the business in the workhouse, leaving the mill, as the paper is no farther connected with it.

As the names have been given heretofore to the several kinds of paper, it may be worthy of observation, that most of *them*, as well as of the departments of the mill, are of French origin, and that they designate probably the advancement of the business from that country, thus: the terms salle, vat, couching, retree, demi, columbeir, grand raisin, grand Jesus, are names in the trade, and of the several kinds of paper which have been given it in that country.

Work-house.

The paper being pressed from the vat, is termed, in water leaf; and this term is given it until it is sized. It is in this state brought into the parting room, where it is laid on the benches, and the preceding day's work is parted sheet by sheet. This room is furnished with the pack presses, generally about four, with screws of a fine thread, so as to press powerfully. The pack room ought to be tight, particularly about the benches, and kept free from any passage for people, or the hands of the mill, as in its wet state the paper is liable to injury.

One parter is generally enough for each vat, and parting the work of the preceding day, is a day's work. By parting the paper, the surfaces of the sheets are changed, and become smooth, the ridges left in them by the wires are displaced, and much flattened. The parters ought always to take out all loose specks, lumps, and moats, which may be on the paper, and which, if they pass this stage of the business, become dried in, and cannot be got out till by the pickers, after it is sized; which is very wrong, as the suface of the paper is injured by taking them out at that time. In addition to this, if the paper becomes broken at this time, by taking out the moats, it can be returned without loss to the engine, but it cannot after it is sized.

In *drawing* paper, and others of fine qualities, the packs are parted a second time, after an intermediate pressure. The pressings are performed, after parting by setting the press full of packs, and pressing by the lever, until the water comes out on the edges of the packs; they must then be left half a day, and pressed again, till it comes out again, and so on for two or three days. The grain by this means is very nicely obtained, and if not done at this time, the paper can never become smooth.

The greatest care should be taken not to press too suddenly; as the presses are very forcible, and the paper may be destroyed by too hard pressing. The sheets are also subject to peel in the parting; the nicest parting is therefore requisite, as, if the sheets are not perfectly true over each other, the edges of the prominent sheets dry sooner when the paper is sized, than the others do, and this is the cause of the rents and fractures, so frequent in the sheets, and of the loss in the manufacture: an excellent *criterion* for judging of the parting being well done, is to pass the dickle over the parted pack: if well done, and none of the pack is uneven, it will pass over the pack to the bottom. When the paper is duly parted, and sufficiently pressed, it ought to be removed into the loft, to be hung, but in this respect attention must be paid to the weather.

If warm weather, of summer, and tolerably fair, the sooner the paper is hung the better, as it is subject to mildew, and

is otherwise insecure; but if wet windy weather, it must be piled away to wait; or if it be like to be freezing weather in the winter, all fine papers will be injured, if hung; but printing and copperplate papers will not injure: and if the papers are of dark shades, the frost will contribute much to whiten them.

Owing to the winter weather and frost, it is, (on account of the packs,) an object with the manufacturer to make considerable lots of thin post papers, the packs not being so large as of the thick papers, they do not accumulate to so great a bulk, and they dry sooner when hung in the spring.

The drying Loft.

This room, being generally the upper story of a mill, is about 14 to 16 feet high, furnished with upright posts in pairs, at about 12 feet space from each other, along each side of a room, and leaving a passage between a row of posts and the side of the room: the distance from the uprights to each other, across the loft, is about 15 to 18 feet; and this space forms the area of what is called the treble rooms, each room being 12 by 15 or 18 feet, according to the breadth of the loft. If the building is very wide, the treble rooms are set double, that is, two sets of them running through the length of the loft, with a passage between them.

The rooms being thus formed of the uprights, the trebles to hold the paper are hung on them as follows: the trebles consist of a light piece of scantling similar to the frame of the side of a bedstead, and bored in the same manner, and hung with cords; that is, a piece of scantling holds the cords reeved through the holes to the opposite treble, and when extended, the ends of each piece rest against the uprights, to prevent the cords swagging across from one to the other. The holes and cords extend across at about a distance from each other of 8 inches; and when thus placed, are pushed up to about the height of a man's head, and secured there by a pin under them, in a hole in the upright, and are ready to receive the paper.

The paper, when hoisted up in the wet packs, is placed on the floor, and one pack at a time on the table. The table is furnished with wheels, and is easily pushed about all over the loft, as the loftsman requires it. The paper is then hung by a few sheets of thick and rather more of thin paper, lifted from the pack by the loftsman with his left hand taking hold of the corner, and slipping under the sheets, a cross in the form of a T, over which the paper hangs, and he puts it up, passing it over the rope, which takes the place of the cross as he draws it away.

The treble ropes ought to be made of coarse hair from the long hair of cows or oxen, as it is soft, and does not injure the texture or surface of the paper; and these ropes being a larger diameter than those of hemp, as well as from the openness of the surface, permit the paper to hang free, and the air to pass under; they also last much longer than the hemp.

The ropes of the lower treble, being filled with paper from one side to the other, it is pushed up the uprights to the top, and another spread in the same manner; and when filled is pushed up to it, so as to leave a space between, for air; and alternately the room is filled, down to about four or five feet of the floor, with more or less trebles, which are all secured in their places, by pins under them in the uprights of the treble rooms: and a room will of course hold more or less of the different layers of trebles, according as the sheets of paper are smaller or larger.

The drying loft is furnished around, with sliding lattice shutters, so as to be closed or opened, as occasion requires. These windows or shutters, extend from the top to near the bottom of the room; and form the sides of the loft. They are closed, in all weather adverse to the drying of the paper, or when the wind is too high, and especially when the sized paper is hung. When the paper is dried, the trebles are brought down in succession, and the paper taken from them and rested in heaps, in one side of the room, ready to go to to the sizing room.

The trebles as they are taken down, are rolled up and put on a low bench, in one side of the loft.

In some fine mills, curtains are hung round the shutters in the cold weather, and by this means, the drying goes on much longer, than when the loft is more open.

The paper when dry, leaves this, for the sizing room, it is however previously jogged, (as the workmen term it,) which is pressing it against the breast, so as to get it free from turning up into hollow spaces, as it comes off the lines, and where it received the shape in which it is hung while drying.

Sizing Room.

This room contains a press, various tubs, boxes, &c. for holding the size, and for sizing the paper; and the cocks or pipes from the sizing and water kettles, ought to open into the adjoining kettle room, which contains the kettles and a

pump; or if possible, a free pipe of clear water.

The size kettle ought always to be made of copper, of about 2 to 300 gallons, about equally deep and broad, and the fire place for the kettle, ought to be constructed on the outside of the building; a window should be near it, to draw off the steam, and to allow the refuse of the pieces to be thrown out, after boiling.

An iron kettle of about 100 gallons, ought to be set in a similar manner for hot water, and a pump to supply it; the size is made from the skins, and also from the feet of animals; the former far preferable to any thing else, and we believe the best and the cheapest, is that from the hides, as bought by the tanners, though at first, of much higher, cost; if any can be had, which may be worm eaten, as is often the case, something may be saved in the price; the hides ought always to be limed, to take off the hair, and they are then ready for soaking for the kettle.

The size is prepared from about 200 pounds of hides, boiled down for about twenty-four hours, regularly kept at the boiling point; the kettle is previously prepared, by putting in it a bottom of straw, and over it a wooden lattice frame, which prevents the size from adhering to the parts, where the fire acts, and being burnt: the pipe to the cock is likewise filled, with a small birch broom, which prevents the pieces from being drawn into it, in running off the size. We have heard of the size being boiled in a hair bag, but it is not in general use.

When the size is sufficiently boiled, which is discovered by the sinking of the pieces, to the bottom of the kettle, it may be drawn off into casks, and is ready for use; when used it is returned into the kettle, and warmed by a gentle fire, is drawn off by the cock into the sizing box, by a long trough, having in it several slides, with fine wire, through which the size is strained in its passage, and several masses of alum, are placed along the trough, which preserves the size, and hardens its effect on the paper, and which the hot size, melts in its passage; a bag is also placed at the end of the trough, and the size is again strained through it, into the sizing box.

The sizing box in which the paper is wet, is an oblong square, about 4½ by 3 feet, and 18 inches deep; it is fixed on the right hand side of the press, with its end near the press-posts; the sizer leans over the box, and taking a convenient handful of the paper, brought from the loft in his right hand, about the middle, opens the bottom of the paper, with his left hand, like rusling the leaves of a book, at the same time, lowering it into the box, so as to introduce the size into the paper: the right hand ought to grasp the paper, first having two wooden slices like rulers, between it and the paper; when the paper is lowered into the size, it will remain a short time without opening, and may be taken up by the opposite end, and the same again loosened, to get the size into it in the same manner; after this, it may be left floating, or rather till it sinks in the size, which if it takes the size, it will do in a short time; it is then to be lifted out by a slice at each end, and handed over to the press, and laid in succession as many handfuls as it will hold conveniently. In the bottom of the press is put a box to catch the size, which runs from the paper, and having a hole in it near the bottom, a bucket is put under the hole, and the size is caught, and returned into the size kettle. The temperature of the size, is also an object of great consequence, it ought to be generally as warm as the hand can bear; too great heat is apt to dissolve the paper, and break it very much, if too cold, it is very apt to size-stain, which is ruinous to it.

It is to be remarked here, that it is much better to have the size continually running, into the sizing box, while the paper is absorbing it, as the paper takes up a large quantity of glutinous matter, and if the box is not supplied, the size becomes weak; it is also of advantage to keep the size in the kettle hot, it would otherwise cool too much. When the press is filled the paper must be pressed, and this screw should be cut so as to fly, and to have a lock like the vat presses. When the paper is moderately pressed, at the sides, it should be well washed down all round, with hot water, which prevents the edges from drying and glueing together; the press is then knocked off, and the paper taken out, and taken into the workhouse to be parted; as it must be parted before it becomes cold; it ought to be covered with a cloth to keep it warm, until it is parted, when parted it ought to stand in packs, till it is cold before it is hung, because otherwise the size is apt to evaporate or fly off, and when hung, the air should be very gentle, as a breeze of wind will stain it, and if the wind blows strong, the size will be driven off entirely; when cold it ought to be taken to the loft without delay, as it is subject to putrefaction; and hung in the same manner as described for water-leafs.

The sizing is the most difficult of the whole process, of paper making, and the most subject to accidental loss; the size if

not made wholly from sound skins, will not render the paper fit for writing, and one skin will injure the whole mass; the heat of the summer, or cold of the winter, are equally ruinous to the operation, and wet retards it; frosts ruin the paper altogether if sized; and paper if sized securely, during the heat of summer, is never hardened till the cold of the fall, or winter. We may here also recommend, that in hot weather when the size is drawn off, into casks or tubs, it has lately been discovered, that if about half a handful of finely powdered rosin is strewed over it, the size will keep for a long time.

When the sized paper is dried in the loft, it is to be taken down and brought into the salle, or finishing room.

Salle or Finishing Room.

This room is generally the best and most extensive part of the mill; it is furnished with the dry presses, perhaps five or six, and with benches round, for the paper pickers and sorters; the foreman of the mill has his station in this room, as has also the finisher; paper when commenced to be finished is to be pressed, which discovers the knots and it also smooths the surface, it is then delivered over by weight to the women, who pick it; a certain weight (differing in each size and kind of paper,) forming a days work; the specks, knots and moats, are here picked out of the sheets, and with as little injury to the surface as possible, the women for this purpose, ought to have a very sharp knife, and it ought to be held much like a pen is held, but at the same time the middle finger ought to have a fine polished thimble, in order to smooth any places, which in turning up the knots become frayed. When all the sheets are thus gone over, the paper is considered picked, and is ready for the sorters. The business of sorting, consists in looking over the paper sheet by sheet, and laying out all the imperfect sheets, into the several parcels, which are as follows.

1st. The whole paper which is considered now free from casualty may go into the hands of the finisher.

2d. The retrea, or defective, is that which has received accidents in the course of the manufacture. It has frequently drops at the vat, frays, blisters, or hems of the coucher, rents, fractures, or peeling of the parters, pulling off the corners, and wrinkles of the hanging. When the papers are sized, all these accidents may again occur, together with the stains of the sizing, and the mildew. The knives of the pickers are very injurious in making holes in the paper, and otherwise injuring its surface. When these defects are very obvious, the paper is sorted into a second or inferior retrea.

3d. The broken, is when the sheets are much fractured or injured in any part of the manufacture.

After the several sorts of paper are placed out, the finisher puts them into the dry presses, where they are pressed for several days, the longer and harder the better, and the surface is astonishingly improved and polished by it.

The paper is then taken out for tying up, for which purpose it is told out, as it is called, into quires of 24 sheets. The man does this by turning up the left hand corner of a few sheets of the pack by a twist of his left hand, and opens them, counting out 24 sheets, by taking a number of four of them in succession between the fingers of his right hand, and when he thus counts the required number, (almost mechanically) lays the quire flat on the table, and the succeeding quire on it, only a little further back; by this means he keeps them all ready for folding when he has a ream of twenty quires, or rather of eighteen quires of perfect, and two quires of broken, (one at each side,) which are always put up for a ream.

It has been for some time the practice, to put up all the paper in half quires, as the sheets lay much better, and make a neater ream.

We mentioned in the day's work of the vat, that a post consisted of five quires, or 125 felts: this allows one sheet in evey quire for loss in the process; and with good workmen it is sufficient; but most generally, in England, twenty-six sheets are made for a quire, or 130 for a post, and it ought to be the same in America: but the custom has obtained, and from this an extra quantity of paper always is lost, and our reams do not turn out in finishing full tale to the account for which the workmen are paid.

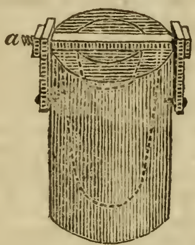
Whenever the paper comes round so whole, as not to make up the two quires in the ream of broken, 18 sheets of retrea are substituted, or 16 sheets of whole paper in each of the outside quires, which is a great saving to the mill.

When the quires are folded and placed on each other to form the ream, they are again pressed hard, with a lay board between each ream, or if small paper, several reams are laid on one board along side of each other, as convenient. When they are thus pressed, they are brought again to the finishing bench, the wrapper is put round them, they are tied with a cord and they are sent to market.

PAPER, *Marbling of.* See MARBLING.

PAPER MARL. See AGRICULTURE, article *Marl.*

PAPIN'S DIGESTER.—In order to dissolve solid animal substances, either partially or totally, a vessel or apparatus is employed which has been invented by Papin. It is made of strong metal, to the thickness of an inch. The inner bottom has an oval shape, as is seen in the figure.



A conical lid is fitted in by grinding, and kept down air-tight by the cross bar and screw, *a*, *b*. Several improvements have been made in this machine, which will be presently noticed.

After putting meat into the digester, together with a sufficient quantity of water, a lid is closely screwed or fastened on, so as to admit no external air. By a moderate fire, the meat will, in the course of six or eight minutes, be reduced to a perfect pulp; by augmenting the heat of the fire, or extending the time of digestion, the hardest bones may be converted into a pulp or jelly. This effect is produced by the most perfect closure of the vessel, which prevents the access or escape of air, so that the reverberations occasioned by the expansion of the aerial fluid, dissolve the whole into an uniform body, and mix the aqueous, saline, oleaginous, and other particles so strongly together, that they cannot be easily separated, but, while hot, appear one liquor, and, when cold, form a jelly of a strength proportionate to the quantity of flesh or bones dissolved in the water.

This useful instrument has not been hitherto applied to culinary purposes; though within the last two years an imperfect imitation of it has been vended in the shops; and we state with satisfaction, that even the latter is incomparably more economical than the various kinds of stew-pans formerly employed. Cast-iron digesters are manufactured of various sizes and prices.

Wilk has given an improvement of the digester in the Swedish Phil. Trans. vol. xxxiv. Messrs. Jackson and Moser have added to it a safety valve.

PARCHMENT GLUE. See GELATIN.

PARCHMENT. In treating of grained parchment, under the article manufacture of grained parchment, and on one or two other occasions, it was mentioned, that parchment was made of the skins of sheep or goats, so as to be subservient to the purposes of binding books, the reception of ink, &c. On the manufacture of parchment, the following observations are given by Dr. Willich.

The wool is first stripped off the skins, which are plunged in a lime-pit, for the space of 24 hours, then taken out, drained, and stretched on a kind of frame; when the flesh is scraped off by means of an iron instrument. Next, they are moistened with a wet rag, then sprinkled with pulverized chalk, rubbed with a pumice-stone, and afterwards with the instrument; when the skins are again moistened, rubbed with the pumice-stone, drained, and the iron instrument is passed a third time over them. The wool, or hair-side, undergoes similar operations; and the whole being carefully extended on the frame, the flesh-side is again scraped: when it is a second time sprinkled with pulverized chalk, which it is afterwards gently brushed off, and the skin again suspended, that it may become perfectly dry.

The next operation is that of paring; when the skins are reduced to one half of their thickness; and rendered smooth by the action of the pumice-stone. The parings are consumed in making size, glue, &c. while the skin is employed for engrossing deeds, and other purposes.

There is a finer sort of parchment, known under the name of vellum, which is prepared from the skins of sucking-calves. It is manufactured in a similar manner, with the first mentioned article, excepting that it is not immersed in the lime-pit. A very excellent glue, or cement, may be obtained by boiling the same shreds of vellum, so as to convert them into a jelly; but care should be taken that no fragments of parchment be used, because the skins of goats and sheep are unfit for such purpose.

A patent was lately granted to Mr. Hitchcock, *for converting old skins of parchment or vellum into leather.* Although we doubt the practical tendency of the patentee's ingenious, but complicated processes; yet, in the present instance, as they may be applied to other useful purposes, we shall observe, that he endeavours first to reduce the skins to their natural state, by washing them well and often in water for 24 hours; then removing them for a similar time, to a bath composed of one

and an half pounds of white vitriol, one pound of cream of tartar, and one ounce of sal ammoniac, dissolved in 20 gallons of water. In order to soften their texture, and to discharge the lime he adds to this liquor, ten pounds of oil of vitriol, one pound of aqua-fortis, and one pint of spirit of salt; in which acid bath, the skins are to be steeped only for a short time. After washing them properly, rinsing out all the acid, and completely wringing out the water, without tearing the skins, they are to be immersed and well soaked, in a tanning liquor, composed of twenty pounds of oak-bark, seven pounds of sumach, five pounds of elm-bark, three pounds of sassafras, and the same quantity of lignum-vitæ shavings, mixed with 20 gallons of water previously warmed, (probably boiled,) for 12 hours, and cooled to the temperature of new milk, before the skins are immersed. Next, they are to be tanned in the common way, with oak-bark, or oak and sumach, then washed and dried.—Lastly, to make the renovated leather water-proof, it should first be soaked for five or six days in linseed or nut-oil; and, after wringing out the superfluous oil, the skin ought to be repeatedly dressed with the following composition: take seven pounds of nut, or linseed-oil; red lead, litharge, sugar of lead, white vitriol, bees-wax, resin, and pitch, one pound of each: melt them together over a moderate fire.

The preservation of deeds written on parchment, is an object that has ever engaged the attention of the lawyer and the antiquary: it is of still greater importance to those who hold estates, or other tenements, in order to enable them to peruse such papers, as have been kept for a series of years, and which, from moisture, or other causes, are almost illegible. To facilitate this desirable object, we select the following, as being the most simple of the many recipes which have been recommended: immerse the parchment obliterated by time, into a vessel of cold water, fresh drawn from a well; in the space of a minute, it should be taken out, and pressed between two blotting papers, to prevent it from shrivelling, while it is drying. As soon as it is moderately dry, (if the characters be not legible) the operation should be repeated, two or three times. Thus, the skin will resume its pristine colour, and appear throughout alike.

PARCHMENT GRAINED. See manufacture of GRAINED PARCHMENT.

PARIAN MARBLE. See MARBLE.

PARING OF LAND. See AGRICULTURE.

PAINT, MILK. See COLOUR MAKING.

PAINTS, spots of, how removed. The use of certain agents for the removal of oil, or spots of grease, &c may be also employed for the removal of spots of paint. The marks of white paint, in particular, may be discharged by moistening or rubbing, the spot or stain with spirit of turpentine, or sulphuric ether,

PAINT. In February 1799, a patent was granted to Mr. Joseph Tidmarsh, for his invention of a compound, which may be either substituted for paint, or mixed with other pigments, for enlarging their quantity, or reducing their price. The patentee directs the following articles to be pulverised, namely; glass, burnt clay, the slag of glass, copper, iron, or other manufactories; marble, spar, flint, or similar vitrefiable or calcareous earths. The powders, thus obtained, may be employed as a paint, with the liquids commonly used in mixing colours; or they may be immediately incorporated with any kind of paint.

The following preparation, however, appears to be more simple, and is equally efficacious; it was first published in the "*Bibliotheque Physico-economique*," for 1792, by M. Ludicke; who has employed it with great success for painting ceilings, gates, doors, and even furniture. He directs fresh curds to be bruised in an earthen pan, or in a mortar; after which they must be mixed with an equal portion of slacked lime: the result will be a white fluid, that may be applied with as much facility as varnish; but it will be necessary to employ such mixture on the same day, as it dries very speedily, and is apt to become too thick, if it be kept 24 hours. He observes that Armenian bole, ochre, and all pigments that are miscible with lime, may be incorporated in various proportions, according to the colour to be communicated; but some caution is necessary, in making such addition, to use the smallest possible quantity of water; as the painting will otherwise be less durable.

When two coats of this paint have been applied, it may be polished with a piece of woollen cloth, or other proper substance; in consequence of which, it will become as bright as any varnish; and if the ceiling, &c. be exposed to moisture, it should be coated with the whites of eggs; by which expedient, it will become as durable as oil painting. The principal advantages, derived from the use of this substitute, consist in its cheapness, and the facility with which the two coats may be

applied, and polished; one day being sufficient for both operations. Hence, it deserves the attention of those whose lungs cannot support the disagreeable smell, arising from oil paint; and who are not disposed to encourage the extravgant charges of the house-painters.

Besides the observations we have given on colours, (see COLOURS) the following additional remarks may be useful.

A Green Paint for inside walls.

Take four pound of Roman vitriol (blue stone) and one pound of Spanish whiting. Put these ingredients (being previously bruised together,) into an earthen vessel, and pour on them some warm rain or soft water. Simmer this over a slow fire for three hours, occasionally stirring it with a stick. Take it off and let it stand; in 24 hours the ingredients will subside, and the water become clear. Pour off the water, and in this state it will keep for years, ready to mix for use at pleasure. When wanted, it must be mixed with water, wherein a small portion of glue has been dissolved, and laid on the walls,(one, two, or three coats) as may seem necessary. Twelve pounds of vitriol, and four pounds of whiting, will give four coats to a wall, 40 feet by 24, and produce a lively and refreshing green.

The following composition is recommended for colouring, and preserving gates, pales, barns, roofs, and timber generally, from the weather.

Melt twelve ounces of resin, in an iron pot or kettle, add three gallons of train oil, and three or four rolls of brimstone; when they are melted and become thin, add as much Spanish, brown or red or yellow ochre, (or any other colour you like, ground fine as usual with oil) as will give the whole the shade wanted. Then lay it on with a brush, as hot and as thin as you can. Some days after the first coat is dried, lay on a second.

It is well attested, that this will preserve plank for years, and prevent the weather from driving through brick work.

Another composition. Take three parts of slacked lime, two of wood-ashes, and one of fine sand, or stone coal ashes; sift these through a fine sand sieve, and add as much linseed oil, as will bring it to a consistence for working, with a painter's brush; great care must be taken to mix the ingredients perfectly. Two coats are necessary; the first may be thin, the second as thick as can conveniently be worked.

PAINTING IN DISTEMPER. Proposed as an advantageous substitute for a new kind of paint, prepared by M. Carbonell.

It is well known that a disagreeable smell is perceived, on entering apartments newly painted in distemper; therefore, till such apartments have been some time exposed, to the contact of the air, no one likes to inhabit them. The following process remedies these two inconveniences.

The method of operation is very simple; it consits in substituting the serum of beef-blood, instead of size, which is usually employed to dilute the colouring matter.

1. The butcher must be requested to catch the blood, of one or more oxen in clean vessels. When the blood is become quite cold, that is, in about three or four hours after it has been drawn, the vessels are gently inclined, and by these means, a transparent liquid is poured off, which has a slight smell of amber. It is strained through a piece of linen, to separate from it the particles of blood, that may be detached and mixed with it.

2. Some quicklime, upon which has been thrown a very small quantity of water only, for the purpose of diminishing the adhesion, of its integral parts, must be reduced to powder. This powder is sifted, and it is instantly put away in boxes or bottles, very carefully closed.

3. When the two above mentioned materials are to be used, the serum must be poured into a wooden or earthen vessel, and a sufficient quantity of the pulverized lime added, to give the mixture such a degree of liquidity, as to be easily spread with the brush over the surfaces, that are to be covered with it.

4. Too great a quantity of this paint, must not be prepared at once, for it very quickly becomes thick; and when it has too much consistence, it cannot be used. This inconvenience is prevented, by keeping it always at the same degree of fluidity, by the addition of a sufficient quantity of serum, which should constantly be kept near the vessel with the paint, to be used as occasion requires.

5. The colour when in this state should be laid on as speedily as possible.

6. As the colour resulting from the application of this preparation, is always white, and one may sometimes wish to have a different colour, it is produced by ochreous earths of the red, yellow, black, or green kinds. A beautiful blue colour may likewise be obtained, by employing blue glass, made with the oxyd of cobalt, provided the glass be reduced, to an impalpable powder.

7. As the addition of coloured ochreous

materials, must necessarily weaken the composition, it may be kept at the same degree of solidity, by adding a few whites of egg, to the serum employed for diluting the composition; but care must be taken, not to add too large a quantity, otherwise the paint would be liable to scale off.

8. This kind of paint, can only be applied on wood or plaster, which have not been previously covered with oil paint.

9. As a single coat is not sufficient, two or three may be laid on, when the work is required to be performed correctly; but before a fresh coat is given, the former must be perfectly dry.

10. This paint is capable of taking a beautiful polish by friction, like any other kind; but it is preferable to dip the cloth, with which it is rubbed, in spermaceti rather than any other kind of oil.

11. For diluting white or coloured paint, only fresh serum, which has undergone no alteration, must be employed; otherwise the paint would be of a worse quality, and less permanent.

Many precautions are necessary, particularly in summer, for keeping the serum, because this fluid is very strongly disposed to putridity. It is therefore essential to keep it in a cool place, and to examine, before it is employed, whether it does not begin to smell disagreeably; for, in that case, it must not be used.

For the same reason, care must be taken to keep the vessels clean, in which the serum is preserved, and to wash them often with warm water, to remove the altered particle of the fluid, with which the sides of the vessel may be impregnated.

M. Carbonell asserts, that this paint is permanent, when prepared with good materials; it may even be employed for painting damp walls, without fear of its being detached, an advantage which painting in distemper, certainly does not possess.

The same author likewise declares, that he has made numerous experiments, with this same paint, and always obtained such constant and satisfactory results, that he doubts not when it is known, that it will be generally adopted. He mentions amongst others, the use he has made of it, at Barcelona, both in the interiour and exteriour of houses, and he has invariably remarked, that it not only remained unaltered by the sun, the air, humidity, and dryness, but that it was also exempt from any disagreeable smell; so that places painted with it, may be inhabited on the very day of applying it.

At first sight one would be led to imagine, that the new kind of paint, proposed by M. Carbonell, is almost the same thing as the milk-paint, described by M. Cadet de Vaux. The latter may have answered, but when we reflect on the material difference, that exists between the composition of the serum of blood, and that of milk, we shall perceive the superiority of M. Carbonell's paint to the other.

For the rest, experience must decide the matter; and it is to be presumed, that it will not fail to show which of the two methods deserves to be adopted in preference.

PALLADIUM. This is a new metal, first found by Dr. Wollaston, associated with platina, among the grains of which he supposes its ore to exist, or any alloy of it with iridium and osmium (two other new metals) scarcely distinguished from the crude platina, though it is harder and heavier. (See PLATINA,) and also an essay by Mr. Cloud, in the American Philosophical Transactions. Palladium has not been introduced into any of the arts.

PALM OIL. See OIL.

PARTING. See ASSAYING.

PASTE, denotes a preparation of wheaten or other flour, boiled up and incorporated with water, till it acquire a viscid consistence. It is used in various trades, as a substitute for size, or glue, in pasting or cementing papers, books, &c. If the composition be intended for paper-hangings, or for other purposes, where a considerable degree of adhesion is required, one fourth, fifth or sixth part in weight, of pulverised resin is added; and, if the paste is to be still more tenacious, gum-arabic, or any kind of size, may be dissolved in the liquid, while the mixture is boiling. As this viscous compound, unless it be preserved in a damp place, is apt to dry speedily, it has been recommended, to dissolve a little sublimate of mercury, (in the proportion of one drachm to a quart,) in the water employed: thus, it will not only retain its fluidity, but will also be secured from the depredations of rats, mice, and other vermin.

There are, however, various and less expensive vegetable substances, that may be aptly substituted for the valuable article of flour; of which considerable quantities are annually consumed in paste.

PASTIL. See DYEING.

PATENTS from the United States, how obtained. As their subjects is important, and may prove of utility to some of our readers, we shall here give the observations of Dr. Thornton on the subject, taken from the National Intelligencer.

Having the honour of directing or superintending the important duties of is-

suing patents for arts and inventions, which formerly were thought worthy of the labours of a council, composed of the secretary of state, the secretary of war, and the attorney general of the United States, I have thought it a duty to my fellow citizens, to publish a few lines of information to facilitate the mode of acquiring patents, by which many will be enabled, to dispense with long journies to the seat of government, or with troubling their friends by a tedious correspondence.

Before an application be made for a patent, I would advise the inventor to examine well the Dictionaries of the Arts and Sciences, the Repertory of Arts, and other publications, that treat of the mechanic arts, to endeavour to ascertain if the invention be new; also to make inquiry of scientific characters, whether or not the invention or discovery be practicable. These previous inquiries, will sometimes prevent great trouble, and save the expense of much time, labour, and money; for a patent does not confer rights, where just claims do not exist; and as there is at present no discretionary power to refuse a patent, even where no just claim exists, it may be proper to caution the purchaser of patent rights, against the supposition, that the invention patented, is always valuable, or new, or that it interferes with no previous patent. The respectable names of the president, the secretary of state, and attorney general are requisite to give validity to a patent; but ought never to be considered in any degree, as evidence of the originality or utility of invention. The issuing of patents is grounded, not only on a desire to promote the progress of useful arts, but also to prevent the loss of valuable secrets; for many have been buried with the inventors, previous to the organization of this system of protection for the property of talent, mind, and genius. Formerly the arcana of any profession, were withheld from the tyro; his initiation was gradual and secret, and the caution with which inventors worked, to prevent the infringement of unprotected rights, confined many important inventions to limits, too narrow to materially benefit either the inventors, or the world: at present the law grants a monopoly to the inventor, for a limited time, provided the art, invention, discovery or machine, be duly explained, deposited, and recorded, for the benefit of mankind, as soon as the time limited has expired; and the patent is not only an evidence, that the inventor has formally confided his secret to the public, but some declaration of the protection of the right, from infringement: nevertheless, of the right, by others, a jury of the country is only competent to decide.

The general law, concerning the issuing of patents will be found in the 2d vol. of the laws of the United States, page 200. This law provides for citizens only; but a subsequent law, vol. 5th, page 88, provides also for applicants, who have resided two years or upwards, in the United States, and who are not citizens.

In applying for a patent, it is necessary to attend to every legal form, for in consequence of inattention to forms only, some of the patents issuing formerly, have in the course of law, been declared null and void.

Mode of Application.

Every inventor before he presents his petition to the secretary of state, signifying his desire of obtaining a patent, shall pay into the treasury of the United States, thirty dollars, for which he will be furnished with duplicate receipts; one of which he shall deliver to the secretary of state, when he presents his petition: and the money thus paid, shall be in full, for the sundry services, to be performed in the office of the secretary of state, consequent to such petition. This petition must be addressed to the secretary of state, and may be in the following or in a similar style.

To the hon. —— —— secretary of state of the United States.

The petition of A. B.— of —— in the county of —— and state of —— respectfully represents— That your petitioner has invented a new and useful improvement, "[or art, machine, manufacture or composition of matter, or any new and useful improvement in any art, machine, manufacture, or composition of matter] in —— not known or used before his application," the advantages of which he is desirous of securing to himself, and his legal representatives: he therefore prays that letters patent of the United States, may be issued, granting unto your petitioner, his heirs, administrators or assigns, the full and exclusive right of making, constructing, using, and vending to others to be used, his said improvement, [art, invention, machine, manufacture, or composition of matter, &c.] agreeably to the acts of congress, in such case made and provided; your petitioner having paid thirty dollars, into the treasury of the United States, and complied with the other provisions of the said acts.

A. B.

[Date.]

The specification or description of the machine, art, discovery or invention, must be given in clear and specific terms, designating it from all other inventions, and describing the whole in such a manner, as to comprehend not only the form and construction, (if a machine) but also the mode of using the same; and if it be only an improvement on a certain machine already invented by the applicant, or any other, it ought to be so mentioned or described: and as this specification, description, or schedule enters into, and forms part of the patent, it must be without any references to a model or drawing, and must be signed by the applicant or applicants, before two witnesses. It is material that this be in good language, and correctly written, as it is transcribed into the patent, and the original papers will be deposited in an office that will hand them down to posterity, by which the honour of the country is concerned in this attention. The modest inventor will no doubt exclude those panegyrics, on the excellence of his invention or discovery, which abound sometimes in the productions of the inferior genius, but which ought not to enter into the patent.

The following or a similar oath or affirmation taken, (before a judge of any of the courts, or a justice of the peace, or any person qualified to administer an oath,) by the applicant or applicants, must be subjoined to the specification, if citizens of the United States.

Form.

County of —— } *ss.*
State of —— }

On this —— of —— 181 before the subscriber, a justice of the peace, in and for the county aforesaid, personally appeared before the above named A. B. and made solemn oath, (or affirmation) according to law, that he verily believes himself, to be the true and original inventor or discoverer of the art, [machine, invention or improvement, composition of matter, &c.] above specified and described, for —— (mention here the object or intention) —— and that he is a citizen of the United States.

J. P.

If not a citizen (or citizens) the following addition must be made to the declaration, that he verily believes himself to be the true and original inventor or discoverer of the art, &c.

And that the same hath not, to the best of their knowledge or belief, been known or used either in this or any foreign country.——" Also that he (or she) hath resided in the United States two years and upwards.

J. P.

The specification must be accompanied by a good drawing, in perspective, of the whole machine or apparatus—" where the nature of the case admits of drawings; or with specimens of the ingredients, and of the composition of matter, sufficient in quantity, for the purpose of experiment, where the invention is of a composition of matter." "And such inventor shall, moreover, deliver a model of his machine, provided the secretary shall deem such model to be necessary." It is requisite, in giving a drawing of the machine, to give also rational drawings of the interior, when the machine is complex; and every drawing should be accompanied by explanatory references. When a machine is complex, a model will likewise be necessary, not only to explain and render it comprehensible to a common capacity, but also to prevent infringements of rights; for many will plead ignorance of drawings, who cannot avoid the conviction of wheels and pinions.

The drawings ought not to exceed a quarto size, and if confined to octavo they would be still better, where it can be done conveniently and distinctly.

Many of the drawings in this office are executed in a very handsome style, and do much credit to the talents of the gentlemen whose names are ascertained. If the artists would always sign them, information might be given to the applicants for patents where to apply for drawings.

Among the best I have received, I notice the names of Messrs. James Akin, Philadelphia; Jacob Cist, P. M. Wilkesbarre, Pennsylvania; Francis Guy, Baltimore; George Hadfield; Nicholas King, city of Washington; Nicholas Peckman, Roxbury, Massachusetts; John R. Penniman, Boston; Archibald Robertson, No. 78, Liberty-street, New-York; Archibald Steward, Hartford, Connecticut; John Stickney, Baltimore; John Stiles, Worcester, Massachusetts; William Strickland, Philadelphia; James Watson, Utica, Oneida county, New-York.

Many being without the names of artists, I cannot do all the justice I wish.

The papers must all be sent under cover to the secretary of state, which of course renders them free of postage; but if models be sent, their freight or carriage hither must be paid; and before packing them, the name or names of the inventor or inventors must be written thereon, with the name of the machine,

and the date; for sometimes on receiving them it is difficult to know to whom they appertain.

The Congress, being impressed with a high sense of the value of the inventions of our citizens, have purchased an elegant and extensive building, wherein preparations are now making for the accommodation of a very numerous collection of machines illustrative of the ingenuity displayed; and this museum of the arts, it is presumed, will stimulate the ingenious to send the models of their machines and inventions in a style that will rather honour than discredit the country.

Copy-rights of books, prints, charts, maps, &c. are secured by depositing before publication, a printed copy of the title of such map, chart, book, or books, in the clerk's office of the district court, where the author or proprietor shall reside, who will record the same; and the author or proprietor shall within two months from the date of the record, cause a copy of the said record to be published in one or more of the newspapers printed in the United States, for the space of four weeks. And within six months after publishing the map, chart, book, or books, the author or proprietor shall deliver or cause to be delivered to the secretary of state, a copy of the same; and when deposited and entered into the patent office, a certificate will be returned of its being received. This will secure the sole right of publication for fourteen years to the author or proprietor, if a citizen of the United States, or resident—" and if, at the expiration of the said term, the author or authors, or proprietors, any of them be living, and a citizen or citizens of these United States, or resident therein, the same exclusive right shall be continued to him or them, his or their executors, administrators, or assigns, for the further term of fourteen years: *Provided* he or they shall cause the title thereof to be a second time recorded, and published in the above manner, within six months before the term of fourteen years aforesaid.

WILLIAM THORNTON.

The number of patents for sundry discoveries, improvements, and applications, are daily increasing, which shews, that the fertility of American genius is always alive, and the patriotism of the people always ready to promote, encourage, and establish, useful improvements for the benefit of the country.

The extensive catalogue of patent rights, the greater part of which have been adopted, exhibits the industry of men, and the zeal for the promotion of the commercial, the agricultural, and the manufacturing interest, as well as a proof of the application of useful science to these purposes.

On the subject of patents, Dr. Mease very properly observes, that the law of the United States respecting patents requires some alterations, which it may be well here briefly to state.

1. Patents should be granted to foreigners as well as to citizens.—The present restriction of our protection to the genius of the latter, is not only illiberal, but highly detrimental to the country, by preventing many ingenious men from divulging their discoveries as soon as they come among us. By pursuing an opposite system, England has become the depot of the inventions and discoveries of all Europe and America: and hence her arts and manufactures have arrived at a degree of perfection, of which no other country can boast.

2. Inventors and discoverers applying for patents, ought to be obliged to secure to the country the advantage of their discoveries, by entering into an obligation to erect or make for sale all their inventions, or to impart a knowledge of them for a reasonable reward: as it is known that many persons are so selfish, as neither to make use of them, nor to grant to others that liberty, unless at an extravagant price, far beyond what the value of the invention would warrant.

3. Some tribunal should be established to determine upon the right which persons may possess to obtain a patent. It is a fact well known, that several persons have obtained patents from the government of the United States, for *supposed* discoveries and inventions which have been long known, or in use in Europe; some of these are noticed in the Domestic Encyclopedia, and more plagiaries might doubtless be detected, if a list of all the patents were published, which have been granted in the United States.

4. Provision should be made for making void the claim of any patentee, as in England, if not supported by originality, or if he wilfully give a confused and erroneous specification.

The editors of the Retrospect of Philosophical, &c. Discoveries, in relation to British patents, vol. 5, p. 554, observes, that the perusal of this specification induces us to advert to the opinion entertained and acted upon by many patentees, namely, that it is only necessary to describe the principle of an invention, without minutely explaining the construction of the machine founded upon it. As it is

the plan and object of this work to afford information on every point connected with patents, for inventions, we deem it consistent with that view to introduce a few remarks, tending to shew the fallacy and danger of such an opinion.

The law, permitting to the crown the privilege of granting patents of monopoly for new inventions, is intended for the public benefit; the reward it offers is held out as an incitement to call genius into exertion for the advantage of the community Every patentee ought to bear in mind, that the monopoly granted him is the price paid by the public for his discovery, and the patent is made on condition of the public being put in complete possession of it, that is to say, the specification required by the letters patent must be made in such manner, that a competent workman may be enabled to construct a machine capable of performing what the title sets forth, without any invention of his own, and without requiring any further instruction than what the specification affords. As the validity of the patent depends on the correctness of the specification, it behoves the patentee to bestow all his care and ability on this object.

To draw up a specification, which shall contain a luminous and minute description of the machine, without limiting the patentee's privilege to any particular modification of the principles on which it is founded, is a task which requires not only talents and technical knowledge, but great experience in the nature of patent-right; and those who have such an undertaking before them, will do well to avail themselves of any assistance they can procure to contribute to its being ably done; for, provided an invention be original, the patentee's security can be affected by nothing but an injudicious or imperfect specification.

PEAT, or TURF, as it is called by some, is a congeries of vegetable matter, in which the remains of organization are more or less visible, consisting of trunks of trees, chiefly oak, fir, birch, alder, hazle, and willow; of leaves and fruits, particularly hazle nuts; and of long stringy fibres, which appear to be for the most part the remains of the sphagnum palustre, and other aquatic mosses. It occurs for the most part in extensive beds called peat mosses, either occupying the surface of the soil, or covered to the depth of a few feet with sand, gravel, and other alluvial matters. It is met with abundantly in the northern and in some of the central districts of Europe, in all moist uncultivated mountainous tracts, as high as vegetation extends; it is also frequent in low vallies and fenny plains; and in several parts of the western shore of Great Britain runs into the sea, to an unknown extent, as in the harbour of Oban, in Argyleshire; in Lancashire, a little to the north of Liverpool; and near Towyn, in Merionethshire. It is found also in some parts of the United States. The depth of peat mosses is very various, from a few feet to twelve or fifteen yards, or even more. The consistence of peat is equally various, being sometimes in a semifluid state, forming a black impassable wilderness, studded here and there by tufts of rushes: when more solid, it is scantily covered over with heath and coarse grasses, and is then passable by sheep and other larger animals, especially during the dry season of the year. In all deep peat mosses, it is found that the upper part of the peat is looser, of a lighter colour, and less inflammable, than that which forms the lower part of the bed. When of a good quality, it is moderately compact, and may readily be cut into solid masses, like bricks, with a sharp thin spade: if it manifests any considerable degree of elasticity and resistance to the spade, its quality is always found to be very inferior. By exposure to the air it dries slowly, being very retentive of moisture, acquires a brownish-black colour, becomes moderately hard, and in this state is very inflammable. By the further action of the weather, it by degrees falls to pieces and is decomposed, though very slowly. When kindled in an open grate, the best kind burns with a yellowish-blue flame almost like charcoal, and a less quantity of smoke than wood affords; it gives out a great quantity of heat, and is reduced to light ashes of a white or reddish yellow colour. Some varieties of peat are considerably changed with iron pyrites, on which account they effloresce and vitriolize when exposed to the air, and in burning give out a strong sulphureous odour, much smoke, and little heat, and afford a reddish-brown ash. Sulphats of soda and magnesia are also occasionally found in peat, and produce a similar bad effect on it, considered as a combustible, as pyrites does.

Many ingenious attempts have been made, especially in France and Germany, to substitute with economy the charcoal of peat for that of wood, for culinary and metallurgical purposes, and it seems to be satisfactorily proved, that a given bulk of the former burns somewhat longer, and affords a more considerable heat, than of the latter; but that it is incapable of withstanding the action of a forge bel-

lows, and is apt to deteriorate the quality of iron that is smelted with it. Another objection, however, occurs to the employment of peat charcoal, on the score of its being less economical, except in very particular circumstances, than wood charcoal. It cannot be prepared in the manner of common charcoal, on account of its loose texture, without a prodigious loss of substance and deterioration of quality; the manufacturer must therefore have recourse to distillation in iron cylinders or other vessels; but to effect this, so large a quantity of peat must be consumed as fuel, that the value of the charcoal, the oil, and ammonia, will hardly cover the expense. Hence it is that all the establishments in France for this purpose, though of considerable magnitude, and carried on with vigour and intelligence, have been entirely abandoned.

Peat is the common fuel of a large part of Wales and Scotland, and of many districts in England, where coal is not readily to be procured. It is employed not merely for domestic purposes, but for burning lime and bricks; and its ashes, though destitute of alkali, are in high estimation as a manure, being applied for the most part in the form of a top-dressing.

PEARL-ASH. See Potash.

PEARLS.—Pearls are a hard, white, shining, usually roundish body, found in a testaceous fish resembling an oyster.

The fish in which these are usually produced is the East Indian pearl-oyster, as it is commonly called. Besides this, the common oyster, the muscle, and several other shell-fish, produce a kind of pearl.

All pearls are formed of the matter of the shell, and consist of a number of coats, spread with perfect regularity, one over another, like the several coats of an onion. They are said to proceed only from a distemper in the fish, analogous to the bezoars, and other stony concretions in several animals of other kinds.

Though these ornaments are met with in all parts of the globe, the most esteemed have always been those of Asia, and the east coast of Africa. In the kingdom of Madura, which lies on the east of Malabar, there are many pearl fisheries. Tutukurin, or Tutucorin, is the principal, if not the only city, on the fishery coast. At the time the Portuguese were masters in these parts, the pearl fishery in the straits betwixt the island of Ceylon and the continent, was stiled, by way of excellence, the fishery, and very deservedly; for, though some prefer the pearls taken near the island of Baharen, in the Persian gulf, and those likewise found on the coast of China at Hainan, yet the produce of these fisheries was very seldom superior to that alluded to. At present the pearl fishery carried on in the strait between Ceylon and the continent is so much exhausted, that it takes generally five or six years before a sufficient quantity of pearls are to be found. The pearls taken at Beharen, though not so white as those of China and Ceylon, are much larger than those of the latter place, and much more regularly shaped than the former. They are of a yellowish cast, but preserve their golden hue; whereas the whiter kind lose much of their lustre by keeping, particularly in a hot climate. The shell of both these species, which is known by the name of *Mother of Pearl*, is used for various purposes. There are a variety of rivers in the Eastern Tartary, considerable for pearl fishery, though defective in shape and colour. Many rivulets in Livonia produce pearls, almost equal in size to the oriental ones. In Scotland, especially to the northward, about Perth, as far as Loch-Tay, in all the rivers running from lakes, there are found muscles that have pearls of more than ordinary merit, though seldom of large size; but this fishery is at present exhausted.

The American pearl fisheries are all in the gulf of Mexico, along the coast of Terra Firma. The greatest quantity, and the finest, both with regard to weight and water, are found about the island of Marguerites. There are also some small pearls in the South sea, particularly in the bay of Panama: but they are very inconsiderable. The West Indians knew the value of their pearls before the discovery of America, and when the Spaniards arrived there, they found great quantities stored up; but they were almost all imperfect, and their water yellow and smoky because they used fire in opening the fish.

There are two seasons for pearl fishing in the East Indies; the first is in March and April, and the last in August and September; and the more rain there falls in the year, the more plentiful are these fisheries. As the oysters are usually firmly fastened to the rocks, the divers commonly take iron rakes down in the sea to loosen them; they also carry down with them a large net, in the manner of a sack, tied to the neck by a long cord, the other end of which is fastened to the side of the bark. This net is to hold the oysters gathered from the rock, and the cord is to pull up the diver, when the bag is full, or when he wants air. He sometimes precipitates himself sixty feet under the water, and whatever depth he be, the light is so great, that he easily sees whatever passes in the sea. To his great con-

sternation he sometimes perceives monstrous fishes, from which al his address in mudding the water, &c. will not always save him, and this is one of the greatest dangers of the fishery. The best divers will keep under water neaar half an hour, and the rest do not stay less than a quarter. During this time, they hold their breath, without the use of oils, or any other liquors. When they find themselves straitened, they pull the rope to be hove up in the air. On the shore they unload their barks, and lay the pearl fish in an infinite number of little pits dug in the sand, raising heaps of sand over them, and in this condition they are left till the rain, wind and sun have obliged them to open, which soon kills them; upon this the flesh rots and dries, and the pearls thus disengaged, fall into the pit on their taking out the shells. After clearing the pits, and cleaning and drying the pearls, they are passed through a kind of sieve, according to their sizes.

Aleppo is the staple place of the East Indian pearls; from thence they are transported to Leghorn, and then circulated through Europe.

PEARL WHITE.—Put some good aquafortis into a Florence flask, and gradually add to it bismuth, broken into small pieces, till no more dissolves; then let the solution remain till it is transparent. Add to this, some water, and a white precipitate will be formed, which is to be washed and dried. This is white oxide of bismuth, commonly termed *magistery of bismuth*, or *pearl white*.

This is used as a cosmetic, and is sold by the perfumers; but it very much impairs the skin, blacking it by degrees, so that once used, it must be continued; and it is also to be feared, that it has besides deleterious effects upon the constitution. See Colour-making.

PEARLS, *Artificial.*—It will not be improper to treat in this place of artificial pearls, as it is a branch of jewellery.

The ancients, who wrote on the several sorts of precious stones, ranged pearls among the jewels of the first class: they have at all times been in high esteem, and have been employed particularly in adorning the fair sex.

The oriental pearls are the finest, on account of their size, colour, and beauty, being of a silver white; whereas, the occidental, or western pearls, seldom exceed the colour of milk. The best pearls are brought from the Persian gulf, above the isles of Ormus and Bassora, called also Balsora, and Basrah. They are found in Europe, both in salt and fresh waters; Scotland, Silesia, Bohemia, and Frisia, (that part of Germany lying between the Rhine and the Ems,) produce very fine ones; though those of the latter country are very small.

Art, which is always busy to mimic nature, has not been idle to bring counterfeit pearls to the greatest perfection: they are imitated so near, that the naked eye cannot distinguish them from pearls of the first class, or the real ones.

We shall here present the curious with several receipts how to counterfeit pearls in the best manner, and after a method both easy and satisfactory, so as to render his labour pleasant, and make it answer his expectations; for which we are indebted to Imison.

To imitate fine Oriental Pearls.

Take of distilled vinegar two pounds, Venice turpentine one pound; mix them together into a mass, and put them into a cucurbit; fit a head and receiver to it, and, after you have luted the joints, set it, when dry, on a sand furnace, to distil the vinegar from it; do not give it too much heat, lest the stuff should swell up.

After this, put the vinegar into another glass cucurbit, in which there is a quantity of seed pearl, wrapt in a piece of thin silk, but so as not to touch the vinegar; put a cover or head upon the cucurbit; lute it well, and put it in *Bal. Mariæ*, where you may let it remain a fortnight. The heat of the *Balneum* will raise the fumes of the vinegar, and they will soften the pearls in the silk, and bring them to the consistence of a paste; which being done, take them out, and mould them to what bigness, shape and form you please. Your mould should be of fine silver, the inside gilt; you must refrain from touching the paste with your fingers, but use silver-gilt utensils, with which fill your moulds; when you have moulded them, bore them through with a hog's bristle, or gold wire, and let them dry a little; then thread them again on a gold wire, and put them in a glass; close it up, and set them in the sun to dry; after they are thoroughly dry, put them into a glass matrass in a stream of running water, and leave them there twenty days; by that time they will contract the natural hardness and solidity of pearls. Then take them out of the matrass, and hang them in *mercury-water*, where they will moisten, swell, and assume their oriental beauty; after which shift them into a matrass, hermetically closed up, to prevent any water coming to them, and let it down into a well, to continue there about eight days; then draw the matrass up, and on opening it you will find pearls exactly re-

sembling oriental ones. This method is very excellent, and well worth the trouble.

It may be necessary to state, that the *Balneum Mariæ*, above alluded to, is a bath of sand, heated by a fire, in which chemical apparatus are plunged, to submit their contents to a digestive heat. It is sometimes called Balneum Maris.

Mercury-water, so called by the workmen, is thus prepared. Take plate-tin of Cornwall, calcine it, and let the calx be pure and fine: then with one ounce of the calx, and two ounces of pure mercury, make an amalgam; wash it with fair water, till the water remains insipid and clear: then dry the amalgam thoroughly; put it into a matrass, on a sand bath, giving it such a heat as is requisite for sublimation. When the matter is well sublimated, take off the matrass, and let it cool. Take out that sublimate; add one ounce of Venice sublimate to it, and grind it together on a marble; put this into another matrass, close it well, and set it upside down in a pail of water; and the whole mass will dissolve in a little time; this done, filter it into a glass receiver; set it on a gentle sand heat to coagulate, and it will turn into a crystalline substance: this beat in a glass mortar, with a glass pestle, to a fine powder; sift it through a fine sieve, and put it into a matrass; stop it close up, and place it in balneum mariæ; there let it remain till it resolves again into water; which is the *mercury-water*, fit for the above mentioned use.

Another way to make Artificial Pearls.

Take oriental seed-pearls; reduce them into a fine powder, on a marble; then dissolve them in mercury-water, or clarified juice of lemons. To make more dispatch, set them in a cucurbit, in bal. mar. and you will see presently a cream arise at the top, which take off immediately: take the solution off the fire, and, when settled, pour off the liquid into another glass, and save it. You will have the pearl paste at the bottom, with which fill your silver-gilt moulds; then put them by for twenty-four hours: bore them through with a bristle; close up the moulds, in barley dough, and put it in an oven to bake, and when about half baked, draw it out, take out your pearls, and steep them in the liquor you saved before, putting them in and taking them out several times; then close them up in their moulds, and bake them again with the like dough; but let it remain in the oven till it is almost burnt, before you draw it out. After you have taken your pearls out of their moulds, string them on one or more gold or silver threads, and steep them in mercury water for about a fortnight: after which time, take and dry them in the sun, in a well-closed glass, and you will have very fine and bright pearls.

Another way.

Dissolve very fine pulverised oriental pearls in alum-water; when the solution is settled, pour off the water, and wash the paste first in distilled water, then in bean water, and afterwards set it in balneum mariæ, or horse-dung, to digest for a fortnight; this done, take out your glass, and the matter being come to the consistence of a paste, mould it as you have been directed before; bore and string the pearls on a silver thread, and hang them in a well-closed glass alembic, to prevent the air coming to them; thus dried, wrap every one up in leaves of silver; then split a barbel, and close them up in the belly thereof; make a dough of barley meal, and bake the fish, as you do bread; then draw him, take out your pearls, and dry them in a closed glass in the sun.

To give them a transparency and splendour, dip them in mercury-water; or, instead take the herb *gratuli*, [probably *gratiola*, i. e. *hedge-hyssop*, is here meant by the unknown term *gratuli*] and squeeze it in water; put therein six ounces of seed pearl, one ounce of nitre, one ounce of roach alum, one ounce of litharge; the whole being dissolved, heat first the pearls and then dip them in this solution to cool; repeat this about six times successively.

If your pearls should not have their natural hardness, then take two ounces of *lapis calaminaris*, in impalpable powder; add to this two ounces of acid of vitriol, and two ounces of whites of eggs beaten into a water; put them together into a retort; lute a receiver to it, and you will distil a fair water, with which, and some fine barley flour, make a paste, in which put your pearls, and bake them as before; thus they will become exceedingly hard.

Another Method.

Take chalk well purified and cleansed from all grossness and sand, *i. e.* whiten; of this make a paste, and form pearls, in a mould for that purpose; pierce them through with a bristle, and let them dry in the sun or in an oven; then string them on a silver thread; cover them lightly over with Armenian bole, diluted in the white of eggs; and when dry, drench them with a pencil and fair water; lay them over with leaf silver, and put them under a glass in the sun to dry; when dry, polish them with a dog's tooth.

To give them the true colour, make a

glue of vellum shavings, thus: after you have washed them in warm water, boil them in fair water, in a new earthen pot or pipkin, to some thickness, and then strain them through a cloth. When you would use it, warm it first, and dip your string of pearls into it, but let there be an interval between each pearl, so as not to touch one another; this will give your pearls a natural lustre.

To make of small Pearls a fine Necklace of large ones.

Take small oriental pearls, as many as you will; put them into mercurial water fifteen days and nights together, and they will turn soft, like a paste; then have a pearl mould, made of silver; into this convey the paste by a silver spatula, or such like implement; but you must not touch the paste with your fingers, and be very careful to have every thing nice and clean about this work: when it is in the mould, let it dry; bore a hole with a silver wire through it, and let it stick there, till you have more, but take care they do not touch one another; then have a glass wherein you may fix, as upon a pair of stands, your wires with the pearls: put them, well closed up, in the sun to harden, and when you find them hard enough, put them into a matrass; lute the neck very close, and sink it in a running spring of water for twenty days, in which time they will contract their natural colour.

It is asserted, by those who have wearied themselves with the hopes of forming small imperfect pearls into larger ones, that artificial pearls cannot be made of the materials of original pearls. The foregoing receipts are laborious and expensive; and that the reader may have some reward for his exertions, should the experiments balk his expectations, we shall add here a tried and approved method of imitating pearls from other materials, which, when well executed, can only be distinguished from the real by their absolutely containing *fewer blemishes.*— The method was kept a profound secret for many years.

Best Method of imitating Pearls.

Take the *blay* or *bleak-fish*, which is very common in some of our rivers, and scrape off, in a delicate way, the fine silvery scales from the belly. Wash and rub these in fair water, changing the water, and permitting the several liquors to settle: the water being carefully poured off, the pearly matter will be found at the bottom, of an oily consistence, called by the French *essence d'orient.* A little of this essence is dropped into a little hollow glass bead of a bluish tinge, and shaken about, so as to fill up all the cavities and surface of the internal part. When the essence is thoroughly dry, melted white wax is dropped into the beads, to give them weight, solidity, and security.

To clean Pearls when of a foul colour.

Take pigeon's dung, moisten it with alum water to the consistence of a paste; put this into a glass, big enough to hold four times the quantity; put into this your yellow-coloured or foul pearls, so that they may be covered all over, and set them in a warm place, or behind an oven; let them stand for a month; then take them out, and fling them into fresh cold alum water, and dry them carefully, and your pearls will become fine and white; if you repeat the operation once or twice, they will be done to greater perfection.

To blanch and cleanse Pearls.

First soak and cleanse them in bran water; then in milk-warm water, and last of all, steep them in mercury water; then string and hang them in a glass; close it well, and set them in the sun to dry.

The bran water is made thus: boil two large handfuls of wheaten bran in a quart of water, till all the strength of the bran is drawn out: use it thus; take a new-glazed earthen pan, in which put your pearls on a string, and pour the third part of the bran water upon them; when they have soaked, and the water is juat warm, rub your pearls gently with your hands, to clean them the better; continue this until the water is cold; then throw off that, and pour on another third part of the bran water that is boiling; proceed with this as you did before, and when cold throw it away, and pour on the remainder of the water, still proceeding as before; after this, heat fair water, and pour it on your pearls, to refresh them, and to wash away the remains of the bran, by shifting them, and pouring on fresh warm water: this do thrice, without handling your pearls; then lay them on a sheet of clean white paper, and dry them in the shade: then dip them into mercury water, to bring them to perfection.

Other Methods used in blanching Pearls.

Pound plaister of Paris to an impalpable powder; rub the pearls therewith very

gently: this will not only cleanse them, but, if you let them remain in this powder twenty-four hours afterwards, they will still be the better for it. White coral has the same effect, used in the like manner.

White tartar, calcined and divested of all its moisture, is very good for the same purpose.

Salt, well dried and ground, is as effectual as any of the former things, for cleansing of pearls, by rubbing them therewith; and if afterwards you lay them up in some ground millet, it will contribute to their natural brightness.

We give the foregoing in the language of Imison; and, as to the truth of the recipes we cannot vouch.

PEDOMETER. See MECHANICS.

PENCILS, Black-lead, are made of a mineral substance called plumbago, or black-lead; a carburet of iron, sawed into slips, and fitted into sticks of cedar. They are of various qualities. The best are fine, without any grit, not too soft, and that cut easily without breaking. An inferior kind is made, by mixing up the dust of black-lead with gum or glue, and forming a composition, which is fitted into sticks in the same manner as the best: these are always gritty, and do not answer so well for most drawings, yet, being cheaper, they may be used upon many occasions. It is necessary to examine pencils before any quantity is bought, by cutting one of them, because the composition-pencils, having the same outward appearance, are often sold for the best.

Black chalk pencil,

Is made of a fossil substance, resembling slaty coal, which is cut into slips for drawing. It is generally used in an instrument called a *port-crayon*, which is made either of steel or brass. It is much employed for drawing figures, and is the best substance for this purpose, in making drawings from plaister, or after the life. It is more gritty than black lead, but is of a deeper black, and has not the glossiness of the former. It is of two kinds, French and Italian; the former is soft, and the latter hard.

Hair pencils,

Are made of camel's hair, put into a goose or swan quill. To choose these, moisten them a little, and if they come to a point without splitting, they are good; if they do not, they are not fit for drawing with. The brushes used by the Chinese, made of a white hair fitted up in reeds, are very excellent for drawing; being much superior for landscapes and many other purposes, to ours made of camel's hair, as they are more elastic. They are not sold here in common, but they may sometimes be met with.

PENDULUM. See MECHANICS and HOROLOGY.

PERNAMBUCCO WOOD. See DYEING and BRAZIL WOOD.

PERSIMMON-TREE, *Diospyros Virginiana*, or American prune, date, or plumb.

A fine transparent gum, of a light-brown colour, insipid to the taste, readily soluble in water, exudes from the body of the tree.

According to Dr. Woodhouse's experiments on this tree, detailed in his *Inaugural Dissertation*, Philadelphia, 1792, it appears, that the juice of the unripe fruit, inspissated in the sun, yields a large quantity of a brown, semi-transparent, astringent, gummy substance, of which common spirit dissolves a larger quantity, than spirit of wine, or the vegetable oils. The unripe fruit divided, well dried in the sun and reduced to powder, may be used as a valuable astringent remedy, [in the forms either of powder, pills, or spiritous tincture,] in all cases requiring astringents.

Use of the Persimmon in the arts.

Dr. Woodhouse says, The unripe juice of the plumb, is preferable to oak bark, for tanning. Allowing every tree to produce four bushels of fruit, and suppose 300 trees cultivated, the quantity of gum resin, which would be produced, would be 1800 pounds, computing six pounds to a tree. The quantity of juice, would be several hundred gallons, which might be kept in barrels till wanted for use. Country tanners should attend to this useful fact.

As a Black Dye.

Dr. Woodhouse, dyed silk with an ink made of this substance, which was as black, and bore washing as well, as that dyed with galls or log-wood.

From an excellent *Memoir* upon this tree, by the late Isaac Bartram of Philadelphia, inserted in the first volume of the American Philosophical Transactions, it appears, that from half a bushel of perfectly ripe fruit, mashed, and mixed with two gallons of water, and fermented with

a small quantity of yeast, he produced half a gallon of proof spirit, of an agreeable flavour. Beer is also made from the fruit in Maryland, by boiling it in water, straining and fermenting it, and adding hops to prevent the fermentation from going too far.

Bread is also made from the fruit, by mixing them as potatoes are with flour, in the case of potatoe bread. The wood of the tree which grows rapidly, burns nearly as well as our favourite hickory, and its ashes yield a large proportion of salts. The great value of this tree ought to induce farmers to cultivate it.

PETRIFACTIONS, Artificial. Put into a quantity of pounded fluor spar, a few bits of broken glass, and pour upon them some sulphuric acid; fluoric acid gas will be disengaged, holding silex in solution. The substances to be made to resemble petrifications, as lizards, frogs, branches of trees, birds nests, &c. must now be moistened with water, and placed in a vessel connected with the neck of the retort. The fluoric acid gas, will be absorbed by the moisture, adhering to the substances, and the silex will be precipitated upon them, like a sort of hoar frost, which will have a very beautiful appearance, and is very durable.

PETROLEUM. See BITUMEN.

PETUNTSE. See PORCELAIN and KAOLIN.

PEWTER, which is commonly called *étain* in France, and generally confounded there with true tin, is a compound metal, the basis of which is tin. The best sort consists of tin, alloyed with about a twentieth, or less, of copper or other metallic bodies, as the experience of the workmen has shown, to be more conducive to the improvement of its hardness and colour; such as lead, zinc, bismuth and antimony. There are three sorts of pewter, distinguished by the names of plate, trifle, and ley-pewter. The first was formerly much used for plates and dishes; of the second are made the pints, quarts, and other measures of beer; and of the ley-pewter wine measures and large vessels.

The best sort of pewter consists of 17 parts of antimony, to 100 parts of tin; but the French add a little copper to this kind of pewter. A very fine silver-looking metal is composed of 100 pounds of tin, eight of antimony, one of bismuth, and four of copper. On the contrary, the ley-pewter, by comparing its specific gravity, with those of the mixtures of tin and lead, must contain more than a fifth part of its weight of lead. This quantity of lead is far too much, considering some of the uses this sort of pewter is applied to; for acid wines will readily corrode the lead of the flagons, in which they are measured, into acetat of lead; which being taken internally, is productive of various chronic diseases, as the colica pictonum, palsies, stupors in the limbs, &c.

It is asserted that English tin is always a mixed metal, when exported abroad: and the French encyclopedists in particular, (Article ETAIN) inform us, on the authority of M. Rouelle, that the English tin, when cast into moulds of six inches in thickness, and cooled, if it be divided into three layers, the uppermost has three pounds of copper in the 100 of tin: the second layer has five pounds of lead, in the same quantity of tin; and the lowest layer has nine of lead in the 100 of tin. Geoffroy had formerly given a similar account of the English tin, with some variety in the doses. But there never was any other foundation for such an assertion, than that pewter has been mistaken for tin abroad: and in fact, all pewter dishes, and all other pewter pieces, are called by the name of tin ware, all over Europe, except in England. Nor could there ever be any advantageous motive to hinder the export of pure tin from England, where it is found in greater abundance than any where else. Beside the above, neither Borlase, nor Pryce, who wrote so minutely on the method, of preparing tin in Cornwall, mention any operation or mixtures this metal undergoes or receives, before or after it is cast in the slabs, blocks, or pieces of tin, in which size and form it is sold, and sent to every market in Europe; so that the whole must be a mistake in terms, as already mentioned, by taking pewter simply for tin. See TIN.

PICTURES.—*A curious method of forming them by nitrate of silver.*—It is well known that light has a powerful effect upon any of the metallic oxides, causing them to turn black.

Mr. J. Wedgewood has availed himself of this property for copying paintings on glass, and making profiles of figures by means of nitrate of silver.

Cover white paper, or leather, with a solution of nitrate of silver, and place it behind a painting on glass, which is exposed to the rays of the run. The rays which come through, will blacken the paper; but the shades will be more or less deep, in proportion to the quantities of light transmitted through the different parts of the glass. Where the glass is transparent, and all the light comes through, the paper will be made quite black; where the glass is quite opaque,

and does not transmit any light, the paper will be quite white; and there will be degrees of intensity of the shadow of every variety between these.

This picture is not sensibly affected by the light of candles or lamps; but the day-light destroys it very soon, causing all the paper to become black; nor have any means hitherto tried for preventing this, been successful.

Besides the application of this property of nitrate of silver to copying the light and shadow of paintings on glass, it may be applied to some others. By means of it, delineations may be made of all such objects as are partly opaque and partly transparent The fibres of leaves, and the wings of insects, may be pretty accurately represented by it, by only making the solar rays pass through them, upon prepared leather or paper.

Professor Davy has found, that the images of small objects produced by means of the solar microscope, may be copied without difficulty on prepared paper. He found that the best proportion was one part of nitrate to about ten of water. This is sufficient to enable the paper to become tinged, without hurting its texture.

The following receipts are given by Imison.

To render old Pictures as fine as new.

Boil in a pipkin, for the space of a quarter of an hour, one quarter of a pound of gray or bril-ash, and a little Genoa soap. Let it cool, so as to be only luke-warm, and wash your picture with it; then wipe it Pass some olive-oil on it, and then wipe it off again. This will make it just as fine as new.

A wash to clean Pictures.

Make a lye with clear water and wood ashes; in this dip a sponge, and rub the picture over, and it will cleanse it perfectly. The same may be done with chamber-lye only; or otherwise, with white wine, and it will have the same effect.

Another Way.

Put iron filings in a handkerchief, and rub the picture with it. Then pass a coat of gum-arabic water on the picture.

The above applications, however, as well as those of soap-water, spirits of wine, turpentine, &c. require to be employed with great care; because they are apt to corrode the oil of the painting, and thus expose the colours to material injury from the slightest friction. Alkaline solutions, or spirituous liquors, therefore, should be used only for particular spots, that have resisted the action of simple water, the oil of olives, or fresh butter. If these substances were timely resorted to, they would, in general, restore the picture to its pristine beauty, without affecting the delicacy of its shades.

To take off, instantly, a Copy from a Print, or a Picture.

Make a water of soap and alum, with which wet a cloth or paper; lay it either on a print or picture, and pass it once under the rolling press; then going round the other side to take it up, you will have a very fine copy of whatever you shall have laid it upon.

Prints, or engravings, may be effectually cleaned by immersing them in weak oxymuriatic acid. See Bleaching.

PICKLE.—A kind of brine or liquor, which is generally prepared of salt and nitre, with the occasional addition of spices, or aromatic herbs, for the preservation and seasoning of flesh-meat. *Pickles* also signify vegetables preserved by the use of vinegar and aromatics.

Under the article Bacon, we have already stated the general requisites to a good pickle: we shall, therefore, only add a few particular directions relative to this subject. It has been ascertained by experience, that the best proportion of salt and nitre to that of *beef*, is the following: Take 8 lbs. of common salt, previously dried in a warm room, and $1\frac{1}{2}$ oz. of saltpetre, likewise in a dry and pulverized state, to every 112 lbs. of meat: let the salts be properly incorporated before they are applied. The beef should be perfectly fresh and cool; as otherwise it cannot be preserved for a considerable time; the cask or vessel ought to be clean, dry, and provided with a moveable lid or cover, so as to support a weight on its top. Much, however, depends on the exact proportion of the saline ingredients in the pickle; and the accuracy with which these compound salts are distributed between the different layers of the meat; for if any cavities remain between the pieces, so that air can penetrate and circulate through the interstices, it will be impossible to keep such meat many weeks in an eatable state.

A similar preparation may be used for *pork*, *mutton*, and *geese;* which last, how-

eveer, should be divided at least into two equal parts. Thus, the farmers in Germany pickle the different kinds of meat above mentioned, together with their beef, in the same vessels; chiefly with a view to fill up the vacant places at the sides, and prevent the corruption of the latter.

PICKLING, *of vegetables*, is one of the modern refinements of luxury, which, in point of healthiness, deserves no commendation. It is effected by employing the strongest vinegar, together with the most heating spices. This compound is rendered still more efficacious by previously boiling the vinegar with cream of tartar, before the aromatics are added. In such state, most vegetable roots, plants, fruits, seeds, walnuts, &c. may indeed be preserved for any length of time, in order to stimulate the palate occasionally; and as it is supposed to promote the digestion of animal food.—It deserves farther to be remarked, that all pickles should be kept in earthen, but *unglazed* vessels; no copper or verdigrease must be employed; the air should be carefully excluded; and the room in which they stand ought neither to be damp nor warm.

It has been the practice, in order to give pickles a beautiful green colour, to throw into the vinegar a copper cent; but the custom is dangerous, and is now abandoned. The vinegar makers, or sellers, have also, on several occasions, in order to render their vinegar preferable, introduced into it oil of vitriol, or sulphuric acid; but this may be readily discovered, on adding to it a clear solution of sugar of lead, which, if it be present, will give a white precipitate.

PIGMENTS. See COLOUR MAKING.

PINCHBECK. See COPPER.

PINS. See MANUFACTURE OF PINS AND NEEDLES.

PINT OIL. See OIL.

PIPES, TOBACCO.—*Manufacture of.* See POTTERY.

PIPE CLAY.---The difference between the porcelain clay and those of more moderate purity, called pipe clays, of which there are plenty in this country and in England, is commonly, that the former remains white when burned in an open fire; but the latter, containing a portion of mineral oil, becomes of a blueish-gray in a moderate heat, by the coal produced by this combustion. A stronger heat, however, will perfectly consume this coal, and restore the whiteness. On the whole, however, it appears rather as if this distinction between the clays used in pottery were grounded on the nature of the product they afford, than on any very evident property ascertainable before they are wrought and baked. See CLAY.

PIPES OF CONDUIT. See HYDRAULICS.

PISOLITE. See LIMESTONE.

PISASPHALTUM. A species of bitumen, which in cold weather is solid, but at other times has a sort of semifluidity. It differs from petroleum only in possessing a greater degree of consistency.

PITCOAL. See COAL.

PITCH. Tar, boiled down to dryness is the common black pitch: this part of the process is commonly performed in a still, in order to have an essential oil, which arises in the boiling, and which is called, from the name of the tree, which tar is principally prepared from, oleum pini, and oleum tædæ. This oil is greatly valued by painters, varnishers, &c., on account of its drying quality: it soon thickens of itself, almost to the consistence of a balsam. Along with the oil, there comes over a watery liquor, which the workmen injudiciously throw away; though it is a good acid, capable of being applied to sundry useful purposes. Neumann knew a person in France, who saved by it several thousand dollars.

Pitch is not a pure and perfect resin; it has not only suffered a notable change, from the heat employed in its preparation, but likewise participates of the other principles of the wood, of a gummy and saline nature, and of a burnt earth. Hence its disposition to separate, and precipitate, when melted with oils, fats, and resins, into plasters and ointments; and hence it is gradually corroded, by air and moisture, when employed as a cement or defence for wood, or other substances, in ships, carriages, cisterns, casks, shingle coverings for houses, &c. Ship builders endeavour to improve their tar and pitch, so as to render them more durable, by various additions.

The soot which arises in the burning of pitch, is the substance commonly sold under the name of lampblack: in France, the pitch is burnt for this purpose, in a kind of furnace made of tiles, so disposed, as to prevent the escape of the smoke.

Lewis informs us, that what is called lampblack, (originally the soot collected from lamps) is obtained, in different parts of Germany, Sweden, &c., not from pure resin or pitch, but from the dregs and pieces of bark of the tree, separated in their preparation. For making common resin, the impure juice collected from incisions, in pines and fir-trees, is boiled down with a little water, and strain-

ed while hot through a sack: on cooling, the resin congeals upon the surface of the water, and is then packed up in barrels; it is distinguished according to its colour, into white, yellow and brown. The dross left on straining, is burnt for lampblack, in a low oven, from which the smoke is conveyed by a long passage, into a square chamber, having an aperture in the top, upon which a large sack is fastened: the soot concretes partly in the sack, which is occasionally removed, and partly in the chamber and passage, from which it is swept out.

PITCH, JEW'S. See BITUMEN.

PLANE, INCLINED. See MECHANICS.

PLAISTER OF PARIS, in agriculture. See AGRICULTURE.

PLAISTER OF PARIS, in moulding. See MOULDING and CASTING.

PLAISTER, OR STUCCO, for outside walls, method of preparing a cheap and durable one, by H. B. Way, of Bridgeport harbour.

Three parts of sand, to one of lime, both finely sifted, and mixed with lime-water; if used as stucco, the first coat to be laid on half the thickness of a crown-piece: let it remain two days, then with a painter's brush, wash it over with strong lime-water, and lay on the second coat, of the same thickness. A coal half-bushel of lime, was put into a hogshead of water, to make the lime-water; to two coal half-bushels more of lime, slacked and sifted, which then measured three half-bushels, were added nine half-bushels of sand sifted, and well mixed with lime-water; the next day it was again mixed up, that it might be well incorporated. The coal half-bushel, contained exactly thirteen gallons of water, wine measure, and would exactly hold 1 cwt. 1 qr. 7 lb. nett of the sand used.

Mr. Way says, that his house is greatly exposed to the spray of the sea, and that by means of the stucco, prepared according to his receipt, it is perfectly free from damp, and that the plaster remains (April 1811,) compact and durable. The work was done in March 1805.

Dr. Mease, in the Archives of Useful Knowledge, says that, it is commonly believed, that plaster made with sea-sand, unless well washed with water, would be always damp, but Mr. Way found from what had been done in his dining parlour and passage, that it was always dry, although the whole of the sand with which it was done, had been thrown up by the sea, and must have been always at spring tides, covered with sea water.

The following facts show that mortar, very freely impregnated with sea salt, is even improved thereby.

Mr. Somerville was informed by the Earl of Wemyss, "that in completing a line of enclosures upon his estates, on the south side of the Frith of Forth, he was under the necessity of using salt water, not only for slacking the lime, but for bringing it to the consistence of mortar, after it was mixed with sand. Contrary to all expectation, the work done with the salt water, took band sooner, than what was done with fresh water, and continues firm."

The Doctor has heard, that a similar agreeable disappointment, was experienced by a gentleman near the sea coast, in Jamaica, from the use of salt water in making mortar. The extraordinary solidity of the Tabby or Tapia walls, of S. Carolina and Georgia, made of shells, shell lime and sand, also, may arise from the salt attached to the shells and sand.

PLATINA. This metal has hitherto been found only in one state, in which according to most mineralogists and chemists, it is considered as native, though Proust is inclined to consider it, as in the state of sulphuret. From this latter opinion, we shall take the liberty to dissent, and shall accordingly describe this substance, as,

Native Platina.

The colour of this mineral is between silver white, and steel grey. It comes to Europe only, in the form of flat, and more or less rounded grains, from the size of a pea, which is rare, to that of fine sand. The surface of the grains is moderately smooth, and they possess rather a low degree of metallic lustre: by friction this brightness approaches to that of polished iron: its hardness is greater than that of copper: it is considerably ductile, and very flexible when in thin plates. Its specific gravity is variable, but is seldom less than 16.5, or greater than 17.2.

It is infusible before the blow-pipe, and is insoluble in acids, except the oxymuriatic or nitromuriatic: from its solution in this latter, it is precipitable by muriat of ammonia, but not by green vitriol.

Nothing is as yet known of the geological situation of this substance, except that it accompanies gold. It is found in the Rio del Pinto, and near Choco, in the Viceroyalty of Peru, and near Carthagena, in New Granada.

A variety of the above in smaller grains and of a darker colour, is also met with.

Platina was first brought into Europe

in 1748, by Mr. Charles Wood, assay-master of Jamaica, and in the succeeding year, specimens were presented by Dr Brownrigg, to the Royal Society. These came from Carthagena, from which place also were dispersed through the Spanish West Indies, various toys and trinkets, consisting of this metal alloyed with some other, probably silver, as the price of the alloy was nearly equal to that of this latter metal.

Analysis of the Ore.

As all the platina which comes to us, has previously undergone the process of amalgamation, in South America, it generally happens, that a small variable quantity of mercury remains in it, sometimes in very small distinct globules, but more generally combined with gold into an amalgam. The easiest way of separating the mercury, is to drive it off by heat, either in an open ladle, or in an earthen retort, according as this substance is, or is not to be retained. When the mercury is thus got rid of, the remaining platina, has generally a much yellower cast than before, on account of the particles of gold dispersed through it, having now acquired their characteristic colour. The ore is now to be spread thin on a smooth table, and by the dextrous application of a common pair of bellows, the lighter particles may be separated, with very considerable accuracy from the heavier ones. The former consist of very minute crystals and fragments of quartz, and of two kinds of iron ore in fragments, and in small octoedrons: of which some are completely attractable by the magnet, (being the magnetic iron sand) while the others are not the least so, and give out when roasted, a slight sulphureous odour

The heavier particles are now to be treated with a small quantity of a somewhat diluted nitromuriatic acid, by which the whole of the gold will be taken up, with some iron and a very small proportion of platina, and the other ingredients. From this solution the gold may be thrown down, by means of green sulphat of iron, and purified by subsequent fusion, with a mixture of nitre and borax. The proportion of gold contained in crude platina, is generally pretty considerable, so as to render it well worth the labour of the chemist, to separate it, if he is possessed of a considerable quantity. From one parcel, consisting of 100 ounces, Proust obtained 7 ounces of gold, and from another like quantity, he procured no less than 13 ounces. The whitest platina is the richest in gold, the black varieties containing little or none of it.

After the separation of the gold, the platina is to be digested into nitromuriatic acid, by which it will be disolved, with the exception of a black matter, which was at first taken for plumbago, but which from Mr. Tennant's recent analysis, appears to be a compound, of two new metallic bodies, that have obtained the names of osmium and iridum. By the addition of muriat of ammonia, to the nitromuriatic solution, the greatest part of the platina, is thrown down in the form of a yellow powder, which is a nearly insoluble ammoniaco-muriat of platina. The solution is now to be treated with zinc, by which all its metallic contents, except the iron, will be precipitated, and this precipitate when washed, is to be digested in very dilute nitric acid: by this menstruum the copper and lead, usually contained in crude platina, will be got rid of, and the remainder is to be dissolved into nitromuriatic acid. To this latter solution, common salt is to be added, and the whole evaporated to dryness. This residual salt contains the soda-muriats of platina, palladium, and rhodium, of which the latter alone is insoluble in alcohol, and may therefore be separated from the former by means of this fluid. The alcoholic solution now contains platina and palladium, from which nearly the whole of the former, is to be separated by sal ammoniac. The solution being now diluted, the addition of prussiat of potash, will throw down the palladium, in the form of a deep orange precipitate, and from the remaining liquor when concentrated, the platina may be precipitated by muriat of ammonia.

Methods of working Platina.

The great infusibility of platina, added to the strong resistance which it opposes to common menstrua, long excited the attention of chemists, and artists, and has given birth to various ingenious processes, for condensing this refractory metal, into malleable masses, and forming of it crucibles and other instruments of material service, to the accuracy and simplici- of chemical analysis. If the largest and whitest grains, are carefully selected from a parcel of crude platina, it will be found that these are considerably malleable even when cold, and still more so when hot: also if two grains are laid in contact with each other, and then brought to the highest possible white heat, they may be made to adhere more or less perfectly, by a stroke with the hammer, and in this way, by great patience, and great dexterity, it may be practicable to form a few grains into a mass. This however, is by

much too imperfect and tedious a method, to be employed with any practical advantage.

It was early discovered that arsenic combined very readily with platina, forming an alloy of easy fusibility, and from the volatility of the former of these metals, especially when in contact with charcoal, it was expected that by proper management, nearly the whole of it might be driven off, leaving the platina behind in a mass, and possessed of its chtracteristic properties. Willis, Marggraaf, Achard, and others succeeded to a certain degree, and fashioned of this alloy, crucibles and other chemical utensils, less fusible than silver, and capable of resisting many of the common menstrua. M. Jeanety of Paris, a working silversmith, then turned his attention to the same object, and after long practice and many failures, discovered by far the best method, of preparing and working this alloy. The process of this artist, as reported by Berthollet and Pelletier, is the following:

Having first gronnd the crude platina in water, and washed it over in order to separate the earthy matters, with which it is mixed; take three half pounds of the metal, three pounds of white arsenic, and one pound of pearl ash: mix the whole well together, and then place in the furnace of any convenient construction, a crucible capable of holding 20 lbs. of the above mixture. As soon as the crucible is thoroughly red hot, pour in one third of the mixture, and keep stirring it with a rod of platina, till it comes into a state of fusion; then add another third, carefully stirring it as before, and after a while add the remaining third, and give the whole a good heat, so as to render it very fluid. Then withdraw the crucible, and after it has cooled, gradually break it up: there will be found a well formed metallic button, covered by blackish brown scoriæ, which acts pretty powerfully on the magnetic needle. This button being broken to pieces, (which is readily done on account of its great brittleness) is to be again fused with white arsenic, and pearl-ash as before, and the metallic mass resulting from this second fusion, is generally incapable of acting on the magnetic needle: if however, this should not be the case, a third fusion with arsenic and alkali, must be had recourse to.

The first step of the process being thus finished, a flat bottomed cylindrical crucible, about $3\frac{1}{2}$ inches in diameter is to be made thoroughly hot in a furnace, and is then to be charged with three half pounds of the arsenicated platina mixed with an equal weight of white arsenic, and half a pound of potash: when these are well mingled and entirely fluid, the crucible is to be removed from the fire, and placed to cool in a horizontal position, in order that the cake of metal may be of an uniform thickness. The crucible, when cold, is to be carefully b oken, and having removed the scoriæ, there will be obtained a cake of metal well formed and sonorous, weighing about three ounces more than the arsenicated platina employed, and now quite saturated with arsenic: there is no danger of incorporating too much of this latter ingredient, it being constantly observed, that the completeness and rapidity of the subsequent purification is exactly in proportion to the quantity of arsenic which it has previously been made to imbibe.

The metallic mass thus procured is to be placed in a muffle, and the heat is to be gradually increased till the arsenic begins to evaporate; the temperature must then be kept up, as nearly as possible the same, for six hours, observing especially not to increase it, lest the cake melt. At the end of this period, the cake will have become considerably porous, and is now to be withdrawn and extinguished in common oil; it is then to be returned to the muffle, by which a further quantity of arsenic will be evaporated, and this alternate application of oil and heating, is to be continued till no more arsenic makes its appearance. The fusibility of the mass diminishes as the arsenic is got rid of, so that a much higher temperature may be employed in the latter, than in the former part of this process. Having carefully burnt off, at a high heat, all the charcoal produced by the decomposition of the oil, the spongy cake of metal is to be digested in nitrous acid, and then edulcorated repeatedly by boiling in water. Three or more of the cakes are then to be put into a cylindrical crucible, and heated to the highest possible degree in a powerful furnace: while they are thus rendered soft, and iron pestle let down upon them will make them cohere: they are then to be withdrawn from the crucible, heated to the utmost in a smith's fire, and carefully forged, like iron, on the anvil into compact bars.

The advantage of this process of M. Jeanety is its cheapness, not requiring the platina to be previously dissolved in nitro-muriatic acid; but on the other hand, the metal, though approaching a state of purity, is by no means absolutely pure: it contains a small quantity of arsenic and iron, together with, probably, the whole of the lead and copper that may have been casually mingled with the

ore, as well as the palladium, osmium, iridium and rhodium, and in consequence of this mixture, is by no means capable of sustaining the action of alkalies and a high heat with so little injury as when more accurately purified.

The next method which we shall mention of purifying this metal, was discovered by count Moussin Pouschkin. It is effected in the following manner. Dissolve the crude platina in nitro-muriatic acid, and throw down the platina by muriat of ammonia, and wash the precipitate in a little cold water. Then heat the yellow powder in a crucible till it is decomposed, and the platina becomes spongy, and returns to the metallic state: now wash the mass with hot water, and boil it in very dilute muriatic acid, to dissolve out any iron that may be casually mixed with it; then edulcorate and dry the residue. Of this residue take a few drachms, with twice its weight of pure mercury, and triturate the mixture in a stone mortar till an amalgam is produced, which may be effected without difficulty: after which, by the alternate addition of mercury and platina, several pounds weight of ingredients may be amalgamated in the course of a few hours. This amalgam, when first made, is soft, but in an hour, or a little more, acquires a considerable hardness; while yet soft therefore, it should be closely rammed into a tube of wood of convenient size, and after it has become hard, the tube with its contents may be placed in a muffle, and by the time that the wooden covering is consumed, a great part of the mercury will be volatilized, so as to prevent all risk of the bar of platina breaking, when deprived of the support of its wooden case. The metal is now to be cautiously heated, till all the mercury is driven off; after which, it is to be forged in the usual way, at the highest possible heat.

A still more simple, and equally effectual, manner of working this metal, has been published by Mr. Knight. The platina being dissolved in nitro-muriatic acid, and precipitated by muriat of ammonia, the yellow powder hence resulting, after being edulcorated by washing in cold water, is to be thus managed. "A strong hollow inverted cone of crucible earth being procured, with a corresponding stopper to fit it, made of the same materials, the point of the latter is cut off about three-fourths of the distance from the point to the base. The platina, in the state of a light yellow powder, is pressed tight into the cone, and a cover being fixed slightly on, it is placed in an air furnace, and the fire raised gradually to a strong white heat. In the mean time the conical stopper, fixed in a pair of iron tongs suitable for the purpose, is brought to a red or a bright red heat. The cover being then removed from the cone, the tongs with the heated stopper is introduced through a hole in the cover of the furnace, and pressed at first gently on the platina, at this time in a state nearly as soft as dough, till it at length acquires a more solid consistence. It is then repeatedly struck with the stopper, as forcibly as the nature of the materials will admit, till it appears to receive no further impression. The cone is then removed from the furnace, and, being struck lightly with a hammer, the platina falls out in a metallic button, from which state it may be drawn, by repeatedly heating and gently hammering, into a bar."

The last method that we shall notice, and one that has been attended with complete success, was invented by Mr. T. Cock, through whose liberality we are enabled to communicate it to our readers.

The platina being dissolved in nitro-muriatic acid, the liquor is to be filtered through clean white sand, in order to separate the black powder which floats among it. The clear solution being then decomposed by sal ammoniac, the yellow precipitate is to be collected, moderately well washed in warm water, and dried. It is then to be distributed into saucers, which are placed in a small oven constructed for the purpose, where they are exposed for a short time to a low red heat, in order to bring the platina to the metallic state, and to drive off, by sublimation, the greater part of the muriated ammonia. When withdrawn, it is a spongy mass of a gray colour. About half an ounce of the platina in this state, is to be put into a strong iron mould about $2\frac{1}{2}$ inches long by $1\frac{1}{4}$ wide, and is to be compressed as forcibly as possible, by striking with a mallet upon a wooden pestle, cut so as accurately to fit the mould; another half ounce is then added, and treated in the same manner; and so on till six ounces have been forced into the mould; a loose iron cover, just capable of sliding down the mould, is then laid upon the platina, and by means of a screw press, almost every particle of air is forced out from among the platina. This is a part of the process that requires especial care, for if any material quantity of air is left in the mass, the bar into which it is formed is very apt, in the subsequent operations, to scale, and be full of flaws. The pressure being duly made, the mould is to be taken to pieces, and the platina will be found in the form of a dense compact parallelo-

piped. It is now to be placed in a charcoal forge fire, and heated to the most intense white heat, in order completely to drive off the remaining ammoniacal muriat; this being done, it is to be quickly placed on a clear bright anvil, and gently hammered in every direction by a clean hammer. This is to be repeated several times, at the end of which the mass will be perfectly compact, and fit to be laminated or wrought in any other manner that the artist chooses. It is to be observed, that while the platina is heating it must lie loose in the fire, for if it were held by the tongs, they would infallibly become welded to the platina, and thus greatly damage it. By the time that the platina is thus drawn down to a compact bar, it will be covered by a somewhat reddish semivitreous crust, proceeding chiefly from particles of the ashes melted down upon it, and extended over its surface by the hammer. To remove this, the bar being made red hot, is to be sprinkled over with pulverized glass of borax, and then kept for a few minutes at a white heat; when moderately cool, it is to be plunged into dilute muriatic acid, by which the borax and other vitreous matter will be dissolved, leaving the platina with a perfectly clean white surface.

Platina has been worked very expeditiously in this city by Dr. Bollman, who had crucibles, spoons, &c. made of it.—For particulars, see Cooper's Emporium. We do not deem it of importance to dwell on the physical and chemical properties of this metal, which belong to the scientific chemist.

Osmium, Iridium, Rhodium, and Palladium.

Of the above four new metals, which have recently been discovered in crude platina, so few particulars have as yet been observed, that we have thought it most advisable to treat of them in an appendix to the article platina.

It has been already mentioned that in dissolving crude platina in nitro muriatic acid, a black powder is separated, which has been supposed by some chemists to be oxyd of iron, by others has been considered as plumbago, but has been lately discovered by Mr. Tennant to contain two new metals. If in treating the crude platina, a large proportion of strong acid at a boiling temperature is made use of, nearly the whole of the black powder is dissolved, and the platina thrown down from the solution by muriated ammonia, instead of being yellow, of a brick red. But if a weaker acid at a much lower temperature is employed, the solution is much less coloured, and nearly 3 per cent. of this black powder remains, which may be readily separated by filtration and washing.

This black matter is partly in scales, and partly pulverulent; it leaves black traces on paper as plumbago does, but differs remarkably from this latter in its specific gravity, which is = 10.7.

If this black powder be mixed with a large proportion of caustic soda, and kept for some time at a red heat, in a silver crucible, the mass acquires a brownish-yellow colour. On the addition of water, a peculiarly pungent odour is extricated, and the alkali, with part of the yellow powder, is dissolved. This alkaline solution contains the oxyds of osmium and iridium, the former of which may be obtained pure, by slightly supersaturating the solution with sulphuric acid, and proceeding to distillation; the metallic oxyd being very volatile, rising with the water, and remaining in solution with this fluid in the receiver: as, however, a little sulphuric acid is liable also to come over, a second very gentle distillation is required to procure the oxyd quite pure. The solution thus obtained is as colourless as water; it has a sweetish taste, and a strong peculiar odour; it does not change vegetable blues to red. Oxyd of osmium may be obtained in a much more concentrated state, by distilling the original black powder with nitre.

We have already mentioned that the black powder obtained from crude platina, contains both osmium and iridium. The method of separating the former has been just now treated of; we shall now, therefore, proceed to show how to procure the latter. Vauquelin's method is, to fuse the black powder with four times its weight of caustic potash, which gives a green saline mass; by digestion with water a green solution is obtained, and some green powder remains undissolved. The alkaline solution is to be saturated with muriatic acid, by which a green precipitate will be obtained, and this, together with the green powder, is to be digested in strong muriatic acid. The deep green muriatic solution, thus prepared, contains the oxyds of iridium, iron, and osmium, and when heated to ebullition, its colour changes to a bright red. It is now to be gently evaporated to dryness, and the residue being treated with alcohol, the muriat of iron will be dissolved, leaving behind a red powder entirely free from this metal. This red powder being calcined at a red heat, in an open crucible, there first arises muriatic acid, and then a vapour which tinges the flame of

the coals of a fine blue, and which doubtless is the oxyd of osmium; a black powder remains behind, which, when mixed with borax, and exposed to a very high heat, is reduced into a half fused granular metal, of a white colour, and very brittle, which is pure iridium.

Mr. Tennant separated the iridium from the other metals with which it is mixed, in the following manner. He treated the black powder alternately with caustic soda, and muriatic acid; the acid solution, consisting chiefly of muriat of iridium, was of a dark-blue colour, which afterwards became of a dusky olive-green, and finally, by continuing the heat, of a deep red colour. By slow evaporation of the solution, only an imperfectly crystallized saline mass was obtained, but this being dried on blotting paper, and again dissolved in water, afforded on evaporation distinct octoedral crystals. These crystals are the pure muriat of iridium, and when dissolved in water give a deep orange-red coloured solution.

All that is hitherto known of the newly discovered metal called Rhodium, has been communicated to the public by Dr. Wollaston. It is thus procured. Some crude platina being digested in moderately dilute nitro-muriatic acid, a brownish-red solution is obtained: from this the platina is to be separated for the most part by muriat of ammonia, and the residual liquor is to be heated with zinc; by this treatment a black powder will be obtained, and the supernatant fluid will consist of the muriats of zinc and iron. This black powder, by digestion in very dilute nitric acid, will be freed from the copper and lead which it usually contains, and the residue is to be digested in dilute nitro muriatic acid, till every thing soluble is taken up. To this solution a little common salt is to be added, and the whole evaporated to dryness; after which, by repeatedly washing with warm alcohol, the soda muriats of platina and palladium will be dissolved, leaving behind a pure soda muriat of rhodium.

An alloy of six parts of gold, and one of rhodium, differs but little in colour from fine gold, but is much more difficultly fusible. The specific gravity of rhodium appears to be somewhat more than 11.

In the preceding account of rhodium, we have mentioned the method of separating the soda-muriat of this metal from the soda-muriats of platina and palladium, by means of warm alcohol. This being done, the alcoholic solution is to be mixed with a solution of muriated ammonia, by which the greater part of the platina will be precipitated: the supernatant liquor being then poured off and diluted, there is to be added prussiat of potash, as long as any precipitate is produced. There is thus obtained a deep orange coloured sediment, which changes by degrees to a dirty bottle green. This, when dried, is to be heated with a little sulphur, and fused into a button, after which it is to be strongly heated with glass of borax, till on cooling it acquires a bright metallic surface; being now separated from the borax and exposed to the flame of the blowpipe, the sulphur is volatilized, and there remains behind a spongy malleable metallic mass, which is pure Palladium.

This metal in its colour greatly resembles platina; when rolled into a thin lamina, it is very flexible, but not very elastic. Its specific gravity varies from 10.9 to 11.9.

PLATING.---The covering of the surface of copper with silver or plating, is performed in the following manner: Upon small ingots of copper, plates of silver are bound with iron wire, generally allowing one ounce of silver to twelve ounces of copper. The surface of the plate of silver is not quite so large as that of the copper ingot. Upon the edges of the copper which are not covered by the silver, a little borax is put; and by exposing the whole to a strong heat, the borax melts, and in melting contributes to fuse that part of the silver to which it is contiguous, and to attach it in that state to the copper. The ingot, with its silver plate, is then rolled under steel rollers, moved by machinery, till it is of a certain thickness; it is afterwards cut to a greater or less extremity, according to the use for which it is intended.

An ounce of silver is often rolled out into a surface of about three square feet, and its thickness is about the three thousandth part of an inch; and hence we need not wonder at the silver being soon worn off from the sharp edges of plated copper, when it is rolled to so great an extent.

What is commonly called French plate, is not to be confounded with plated copper. French plate is made by heating copper, or more commonly brass, to a certain degree; silver-leaf is then applied upon the heated metal, to which it adheres by being heated with a proper burnisher. See Silvering.

PLUMBAGE. See Coal.

PLUMBING. See Manufacture of Lead.

PLUME. See Manufacture of Military Feathers, &c.

PNEUMATIC COCK, is a simple, in

genious, and useful contrivance for tapping air-tight casks, which obviates the necessity of a vent peg. The inventor, Mr. Robert Hare, jun. in giving a description of this invention, observes, "it is well known that an air-tight cask is usually tapped by means of two apertures, one in the upper part for the admission of air, the other below for the emission of the fluid; or, in other words, by means of a vent peg and cock. This method would not be very objectionable, were the vent peg always firmly replaced as soon as the admission of air becomes no longer necessary; but this is seldom attended to, and the consequence is the frequent sourness or vapidity of vinous liquors. The quantity of liquor thus annually spoiled by this omission of vent pegs, must be immense; and must be particularly great in those families where tapsters are too numerous to be responsible for neglect.

To obviate these evils, Mr. Hare has contrived a cock with two perforations, which are opened or shut by turning the same key, the air entering at the upper perforation the fluid passing out at the lower, with a velocity proportioned to the depth of the emitting orifice below that which admits the air into the cask. The fixed air, however, which is generated in casks containing vinous liquors will sometimes more than counteract the pressure of the atmosphere, and thus dispose the liquor to issue through every aperture. In this case, while the cock is open, it will be necessary to close the upper orifice with the thumb, while the fingers are holding the key.

The cock must be of a bended form, so that the key may be situated below the orifice which receives the liquor, and the nozle should taper downwards in order to give a sufficient velocity to the fluid from the cask.

POISONS.---The principal part of the following observations we have taken from Henry's Chemistry.

Method of detecting Poisons.

When sudden death is suspected to have been occasioned by the administration of poison, either wilfully or by accident, the testimony of the physician is occasionally required to confirm or invalidate this suspicion. He may also be sometimes called upon to ascertain the cause of the noxious effects arising from the presence of poisonous substances in articles of diet; and it may therefore serve an important purpose, to point out concisely the simplest and most practicable modes of obtaining, by experiment, the necessary information.

The only poisons, however, that can be clearly and decisively detected by chemical means, are those of the mineral kingdom. Arsenic, and corrosive sublimate, [I use the term arsenic, instead of the more proper one, arsenous acid; and corrosive sublimate, for muriate of mercury; because the former terms are more generally understood,] are most likely to be be exhibited with the view of producing death; and lead and copper may be introduced undesignedly, in several ways, into our food and drink. The continued operation of the two last may often, unsuspected, produce effects less sudden and violent, but not less baneful to health and life, than the more active poisons; and their operation generally involves, in the pernicious consequences, a greater number of sufferers.

Method of discovering Arsenic.

When the cause of sudden death is believed, from the symptoms preceding it, to be the administration of arsenic, the contents of the stomach must be attentively examined. To effect this, let a ligature be made at each orifice, the stomach removed entirely from the body, and its whole contents washed out into an earthen or glass vessel. The arsenic, on account of its greater specific gravity, will settle to the bottom, and may be obtained separate by washing off the other substances, by repeated affusions of cold water. These washings should not be thrown away till the presence of arsenic has been clearly ascertained. It may be expected at the bottom of the vessel in the form of a white powder, which must be carefully collected, dried on a filter, and submitted to experiment.

(A.) Boil a small portion of the powder with a few ounces of distilled water, in a clean Florence flask, and filter the solution.

(B.) To this solution add a portion of water, saturated with sulphuretted hydrogen gas. If arsenic be present, a golden-yellow sediment will fall down, which will appear sooner, if a few drops of acetic acid be added.

(C.) A similar effect is produced by the addition of sulphuret of ammonia.

(D.) To a little of the solution (A.), add a single drop of a weak solution of carbonate of potash, and afterward a few drops of a solution of sulphate of copper. The presence of arsenic will be manifested by a yellowish-green precipitate; or boil a portion of the suspected powder with a dilute solution of pure potash, and with this precipitate the sulphate of c op per, when a similar appearance will en

sue still more remarkably, if arsenic be present. The colour of this precipitate is perfectly characteristic. It is that of the pigment called Scheele's green. To identify the arsenic with still greater certainty, it may be proper, at the time of making the experiments on a suspected substance, to perform similar ones, as a standard of comparison, on what is actually known to be arsenic. Let the colour, therefore, produced by adding an alkaline solution of the substance under examination, to a solution of sulphate of copper, be compared with that obtained by a similar admixture of a solution of copper with one of real arsenic in alkali.

(E.) The sediments, produced by any of the foregoing experiments, may be collected, dried, and laid on red-hot charcoal. A smell of sulphur will first arise, and will be followed by that of garlic.

(F.) But the most decisive mode of determining the presence of arsenic, is by reducing it to a metallic state, in which its characters are clear and unequivocal. For this purpose, let a portion of the white sediment, collected from the contents of the stomach, be mixed with three times its weight of black flux; or, if this cannot be procured, with two parts of very dry carbonate of potash (the salt of tartar of the shops,) and one of powdered charcoal. Procure a tube eight or nine inches long, and one sixth of an inch in diameter, of thin glass, sealed hermetically at one end. Coat the closed end with clay, for about an inch, and let the coating dry. Then put into the tube the mixture of the powder and its flux, and if any should adhere to the inner surface, let it be wiped off by a feather, so that the inner surface of the upper part of the tube may be quite clean and dry. Stop the end of the tube loosely, with a little paper, and heat the coated end only, on a chafing-dish of red-hot coals, taking care to avoid breathing the fumes. The arsenic, if present, will rise to the upper part of the tube, on the inner surface of which it will form a thin brilliant coating. Break the tube, and scratch off the reduced metal. Lay a little on a heated iron, when, if it be arsenic, a dense smoke will arise, and a strong smell of garlic will be perceived. The arsenic may be farther identified, by putting a small quantity between two polished plates of copper, surrounding it by powdered charcoal, to prevent its escape, binding these tightly together by iron wire, and exposing them to a low red heat. If the included substance be arsenic, a white stain will be left on the copper.

(G.) It may be proper to observe, that neither the stain on copper, nor the odour of garlic, is produced by the white oxide of arsenic, when heated without the addition of some inflammable ingredient. The absence of arsenic must not therefore be inferred, if no smell is occasioned by laying the white powder on a heated iron.

The late celebrated Dr. Black ascertained, that all the necessary experiments, for the detection of arsenic, may be made on a single grain of the white oxide; this small quantity having produced, when heated in a tube with its proper flux, as much of the metal as clearly established its presence.

If the quantity of arsenic in the stomach should be so small, which is not very probable, as to occasion death, and yet to remain suspended in the washings, the whole contents, and the water employed to wash them, must be filtered, and the clear liquor assayed for arsenic by the tests (B.) (C.) (D.) and (E.)

Discovery of Corrosive Sublimate.

Corrosive sublimate (the muriate of mercury) next to arsenic, is the most virulent of the metallic poisons. It may be collected by treating the contents of the stomach in the manner already described; but as it is more soluble than arsenic, viz. in about 19 times its weight of water, no more water must be employed than is barely sufficient, and the washings must be carefully preserved for examination.

If a powder should be collected, by this operation, which proves, on examination, not to be arsenic, it may be known to be corrosive sublimate by the following characters.

(A.) Expose a small quantity of it, without any admixture, to heat, in a coated glass tube, as directed in the treatment of arsenic. Corrosive sublimate will be ascertained by its rising to the top of the tube, lining the inner surface in the form of a shining white crust.

(B.) Dissolve another portion in distilled water; and it may be proper to observe how much of the salt the water is capable of taking up.

(C.) To the watery solution add a little lime-water. A precipitate of an orange-yellow colour will instantly appear.

(D.) To another portion of the solution add a single drop of a dilute solution of carbonate of potash (salt of tartar). A white precipitate will appear; but, on a still farther addition of alkali, an orange-coloured sediment will be formed.

(E.) The carbonate of soda has similar effects.

(F.) Sulphuretted water throws down

a dark-coloured sediment, which, when dried and strongly heated, is wholly volatilized, without any odour of garlic.

The only mineral poison of great virulence that has not been mentioned, and which, from its being little known to act as such, it is very improbable we should meet with, is the carbonate of barytes. This, in the country where it is found, is employed as a poison for rats, and there can be no doubt would be equally destructive to human life. It may be discovered by dissolving it in muriatic acid, and by the insolubility of the precipitate which this solution yields on adding sulphuric acid, or sulphate of soda. Barytic salts, if these have been the means of poison, will be contained in the water employed to wash the contents of the stomach, and will be detected, on adding sulphuric acid, by a copious precipitate.

Method of detecting Copper or Lead.

Copper and lead sometimes gain admission into articles of food, in consequence of the employment of kitchen utensils of these materials.

I. If copper be suspected in any liquor, its presence will be ascertained by adding a solution of pure ammonia, which will strike a beautiful blue colour. If the solution be very dilute, it may be concentrated by evaporation; and if the liquor contain a considerable excess of acid, like that used to preserve pickles, as much of the alkali must be added as is more than sufficient to saturate the acid.

II. Lead is occasionally found, in sufficient quantity to be injurious to health, in water that has been kept in leaden vessels, and sometimes even in pump-water, in consequence of this metal being used in the construction of the pump. Acetate of lead has also been known to be fraudulently added to bad wines, with the view of concealing their defects.

Lead may be discovered by adding, to a portion of the suspected water, about half its bulk of water impregnated with sulphuretted hydrogen gas. If lead be present, it will be manifested by a dark-brown, or blackish tinge. This test is so delicate, that water, condensed by the leaden worm of a still-tub, is sensibly affected by it. It is also detected by a similar effect ensuing on the addition of sulphuret of ammonia, or potash.

The competency of this method, however, to the discovery of very minute quantities of lead, has been lately set aside by the experiments of Dr. Lambe, the author of a skilful analysis of the springs of Lemington Priors, near Warwick. By new methods of examination, he has detected the presence of lead in several spring-waters, that manifest no change on the addition of the sulphuretted test; and has found that metal in the precipitate, separated from such waters by the carbonate of potash or of soda. In operating on these waters, Dr. Lambe noticed the following appearances.

(*a*) The test forms sometimes a dark cloud, with the precipitate affected by alkalies, which has been redissolved in nitric acid.

(*b*) Though it forms, in other cases, no cloud, the precipitate itself becomes darkened by the sulphuretted test.

(*c*) The test forms a white cloud, treated with the precipitate as in (*a*). These two appearances may be united.

(*d*) The test neither forms a cloud, nor darkens the precipitate.

(*e*) In the cases (*b*), (*c*), (*d*), heat the precipitate, in contact with an alkaline carbonate, to redness; dissolve out the carbonate by water; and treat the precipitate as in (*a*). The sulphuretted test then forms a dark cloud with the solution of the precipitate. In these experiments, it is essential that the acid, used to redissolve the precipitate, shall not be in excess; and if it should so happen, that excess must be saturated before the test is applied. It is better to use so little acid, that some of the precipitate may remain undissolved.

(*f*) Instead of the process (*e*) the precipitate may be exposed without addition, to a red heat, and then treated as in (*a*). In this case, the test will detect the metallic matter; but with less certainty than the foregoing one.

The nitric acid, used in these experiments, should be perfectly pure; and the test should be recently prepared, by saturating water with sulphuretted hydrogen gas.

Another mode of analysis, employed by Dr. Lamb, consists in precipitating the lead by muriate of soda; but as muriate of lead is partly soluble in water, this test cannot be applied to small portions of suspected water. The precipitate must be, therefore, collected from two or three gallons, and heated to redness with twice its weight of carbonate of soda. Dissolve out the soda; add nitric acid, saturating any superfluity; and then apply the sulphuretted test.

The third process, which is the most satisfactory of all, and is very easy, except for the trouble of collecting a large quantity of precipitate, is the actual reduction of the metal, and its exhibition in a separate form. The precipitate may be mixed with its own weight of alkaline

carbonate, and exposed either with or without the addition of a small proportion of charcoal, to a heat sufficient to melt the alkali On breaking the crucible, a small globule of lead will be found reduced at the bottom. The precipitate from about fifty gallons of water yielded Dr. L. about two grains of lead.

For discovering the presence of lead in wines, a test, invented by Dr. Hahnemann, and known by the title of Hahnemann's wine-test, may be employed. This test is prepared by putting together, into a small phial, sixteen grains of sulphuret of lime, prepared in the dry way, and 20 grains of acidulous tartrite of potash (cream of tartar). The phial is to be filled with water, well corked, and occasionally shaken for the space of ten minutes. When the powder has subsided, decant the clear liquor, and preserve it, in a well-stopped bottle, for use. The liquor, when fresh prepared, discovers lead by a dark-coloured precipitate. A further proof of the presence of lead in wines, is the occurrence of a precipitate on adding a solution of the sulphate of soda.

The quantity of lead, which has been detected in sophisticated wine, may be estimated at forty grains of the metal in every fifty gallons.

When a considerable quantity of acetate of lead has been taken into the stomach, (as sometimes, owing to its sweet taste, happens to children) after the exhibition of an active emetic, the hydro-sulphurate of potash or of ammonia may be given; or a solution of the common sulphuret.

In cases of the accidental swallowing of sulphuric acid, which also sometimes happens to children, M. Fourcroy recommends the speedy administration of a solution of soap, or a mixture of carbonate of magnesia or carbonate of lime (common chalk) with water.

POLARITY of the Magnet. See Magnetism.

POLISHING.---We have heretofore noticed the use of different substances for polishing bodies. It is hardly necessary, therefore, to say much in this place. Besides the use of different mineral and vegetable bodies, we shall only observe, that one of the most proper articles, in this respect, is the *Asphodelus luteus*, L. or the Common Yellow Asphodel....The stalks of this plant are somewhat thicker than a goose-quill; and when dipped in Colcothar, or *Crocus Martis*, (which may be had of the druggists,) reduced to a paste with sweet-oil, and properly applied to iron and brass utensils, will not only render them exceedingly bright, but also prove a better preservative from the rust, than sand-paper, or other rough materials.

POPPY. See Opium.

POPPY-SEED OIL. See Oil.

PONDEROUS EARTH. See Barytes, article Earths

PORCELAIN. See Pottery.

PORCELAIN, Reaumur's. See Glass.

PORK, is the flesh of hogs killed for culinary purposes. For sundry observations on the means of curing pork, as well as other animal substances, we refer to the articles Beef, Bacon, Pickle, &c. We shall add, however, the following mode of pickling pork, which is mostly adopted in this country.

First, cut the flesh into long pieces, about an inch and a half thick; and, after sprinkling it with salt, and suffering it to remain in that state for 24 hours, these slices are next dried in stoves till they acquire a bony hardness, and a deep brown colour. Pork, treated in this manner, if packed in casks, may be preserved for upwards of a whole year; and, when soaked in luke-warm water, becomes plump, and has a rosy appearance. It likewise possesses a grateful flavour under the various forms of cookery, and is relished by the most delicate palate.

Beside the usual manner of curing pork with bay-salt, some housewives add juniper-berries, pepper, *nitre*, and other antiseptic substances. Saltpetre, when used in small proportions, is peculiarly calculated to resist putrefaction. See Pickle

PORTABLE VINEGAR.---Several methods have been proposed to render vinegar portable; but the custom is not prevalent, and we think, when used, but of little advantage. The concentration of vinegar by congelation, and by distillation, in order to free it of water, has been preferred: the decomposition of certain acetites by distillation, in order to obtain acetic acid, or radical vinegar, is the best mode of concentrating the acid, or of preserving it in a state necessary for considerable dilution. One ounce of which will afford, by dilution with water, better than a pint of strong vinegar. The following receipt for making portable vinegar is given by Imison.

Take green grapes, and stamp them, and put some vinegar to them, making it into a sort of paste or dough, whereof you form little loaves, and lay them in the sun to dry. When they are thoroughly dry, put them up for use. You steep these little loaves in as much wine as you think sufficient for present use, and you

have a very good strong vinegar. See VINEGAR.

PORTER.---Although we have given some general observations on beer and porter, in the article on brewing, yet we deem it of importance to introduce in this place the following recipe, which we have taken from Child's late treatise, entitled, *Every man his own Brewer*, viz.

One peck of malt,
A quarter of a pound of liquorice-root,
Spanish juice,
Essential bina,
Colour,
Half a pound of treacle,
A quarter of a pound of hops,
Capsicum and ginger.

These articles are to be managed as directed in the article Brewing, and will produce six gallons of good porter.

For the information of those who may be totally unacquainted with the process of brewing porter, we shall add a short explanation of the manner in which the *essentia bina* and the *colour* are prepared. In order to procure the first of these ingredients, a quarter of a pound of moist sugar, should be boiled in an iron vessel, till it attain to the consistence, of a thick black syrup, which is remarkably bitter. The colour is produced by boiling a similar quantity of moist sugar, till it acquire a taste between sweet and bitter: it imparts the fine mellow tint, that is so much admired in good porter.

POTASH. PEARL ASH, SALT OF TARTAR. In this article we shall first treat of the method of procuring the vegetable fixed alkali, and the different forms under which it appears in commerce, and domestic use. By the name, potash is now commonly distinguished, that alkali which was formerly called fixed, to distinguish it from ammonia, and vegetable, as it was supposed to be peculiar to that kingdom: though it has been found of late in various stones, and in small quantities even in animal substances; at a red-heat it is volatilized. From the article known in commerce, by the name of potashes, which consist chiefly of this alkali, though in a very impure state, the French neologists termed the alkali potasse, whence our potash is derived; though this has the inconvenience of rendering the pure alkali, to be confounded with the heterogenous compound, from which it is extracted. The names of lixivia, given it by Dr. Black, tartarin, by Kirwan, vegalkali, by Dr. Pearson, and kali, by the London college, are not open to this objection; but neither of them has been adopted by other chemists. Some have retained the French word without alteration, others have altered its termination merely; and perhaps potassa is the preferable term, though we have followed the current of the more general usage.

The vegetable fixed alkali, was so named by the chemists, of the last and former ages, because it was procured in large quantities from vegetable substances, and was in no case supposed to be of mineral origin. From certain late analysis, however, by Klaproth and other able chemists, it has been discovered to enter, as an essential ingredient, into the composition of leucite, lepidolite, and a few other minerals, which are by none suspected, of deriving their origin from organized bodies. But though the existence of potash in a mineral state has been thus demonstrated, yet it is so small in quantity, and so difficultly procurable, that all the vast supplies of this substance, which civilized life requires, have as yet been entirely obtained, from the combustion of vegetables.

If the woody or annual stems of vegetables, that have grown in soils unimpregnated with common salt, after being sufficiently dried, are set fire to, the watery, the resinous, the oily, the acid and carbonaceous portions, are volatilized and dissipated, in a state of more or less complete decomposition, and there remains behind, a reddish or whitish powder, called ash or ashes: consisting chiefly of the earthy, and metallic ingredients of the vegetables, together with a variable proportion of sub-carbonat of potash. By lixiviation with hot or cold water, the alkaline part is dissolved out, and this solution when boiled down to dryness, leaves behind a dark brown saline mass, consisting of the carbonated potash, coloured by a small portion of vegetable inflammable matter; and in this state it is known in the English market, by the name of potash. Calcination at a moderate red heat, completely burns off the colouring particles, and the salt becomes of a spungy texture, and beautiful bluish white tinge, and is then called pearlash. Such is in general, the process by which the vegetable fixed alkali, is separated from the substances with which it is combined by nature, and prepared for use. We shall now proceed to describe, more at large the different methods of extracting this salt, together with the precautions that are necessary to secure the greatest success.

The simplest and rudest preparation of potash, is called ash-balls in England, and weed-ash in Ireland. It cannot be said, properly speaking, to be an article of commerce, although a considerable quantity

is annually made by the peasantry of both countries, and disposed of among the neighbouring farmers and bleachers. The vegetable from which this impure alkali, is produced is the common fern or brakes, (Pteris aquilina Lin.) Many rough and heathy districts, are entirely covered with this plant, which when it has attained its full growth, (which happens about the middle of July) is cut down, and after being half-dried in the open air, is gathered into small heaps and kindled. The combustion proceeds slowly, being accompanied by a smothering smoke, and little or no flame, till the whole is reduced to a reddish gray ash : this being carefully collected, is sprinkled with a little water, and then moulded by hand into balls, from three to four inches in diameter, which when they have acquired a certain hardness and solidity, by drying in the sun, are ready for sale. In Ireland, thistles, docks and weeds of all kinds, are mixed with the fern, and the ashes are disposed of, in their loose pulverulent state, without any further preparation. According to Dr. Home, fern-ashes contain about one-ninth of their weight of salt, consisting principally of sub-carbonat, and sulphat of potash. One thousand parts of the plant cut in August, and thoroughly dried, afford 36.46 of ashes, from which are obtained by lixiviation 4.25 of salt. The common Irish weed ashes, have been analized by Mr. Kirwan ; and when deprived of their water by a red heat, appear to contain one part of salt, for three and an half parts of ash ; of this the free alkaline portion however, as deduced from the quantity of alum, decomposed by the lixivium, amounted only to one-twenty-second of the whole.

The potash of commerce, or black potash, as it is also called, is universally procured from the combustion of wood ; and therefore its preparation can only be undertaken with success, in those uncleared countries, in which are vast natural forests, and where from the badness of roads, and imperfection of water communication, the value of timber is no more than that of the labour employed in felling it. The only districts in Europe, in which any considerable quantity of potash is made, are the mountainous forests of Germany, and the extensive woodland tracts of Poland and Russia. The British market is principally supplied from the United States of North America ; a country in which from its rapid increase in population, there is a constant demand for cleared land for the purpose of cultivation, and therefore timber is looked upon rather as an incumbrance, than as contributing either to the beauty, or value of the ground on which it stands.

The most wasteful method of manufacturing potash, is that practised by the Americans, partly on account of the ignorance of the people, by whom it is prepared, but principally because this employment is carried on rather as subsidiary to clearing the ground for agriculture than on its own account. The wood as soon as it is sufficiently dry to burn, is collected into large piles, and reduced to ashes: these ashes are then put into a wooden cistern, with a plug at the bottom of one of the sides, and a quantity of water, sufficient to make a strong lixivium is added : after standing for an hour or two, the plug is withdrawn, and the water holding the potash in solution runs clear out, leaving the earthy part still impregnated with alkali in the cistern. This solution is then evaporated to dryness in iron pans, and hastily fused into compact reddish brown, masses of semi-caustic potash, in which state it is fit for the market.

In Germany, where potash is prepared (on its own account,) and where a greater degree of intelligence and economy is practised, the general method of proceeding is the same as that just mentioned, but with such variations as, though seemingly of little consequence, materially augment the produce of alkali. Care is taken to select such kinds of wood as are the richest in potash; the combustion is slower, and of course the temperature lower, in consequence of which but little is lost by volatilization ; the lixiviations of the ashes, are also judiciously repeated till the whole of the alkali is extracted.

The common Russian potash is the impurest of all, containing nearly one half its weight of earth, and is thus prepared. A large pit is dug, into which are thrown burning brands, and the smaller extremities of the branches, and when the whole is well kindled, the pit is filled up with logs and other large pieces, which at length, though very slowly, are reduced to ashes. The coarser part of the ashes, is then separated by sifting from the finer; all the alkali that it contains, is procured by lixiviation ; and this liquor is mixed with the remainder of the ashes, and worked together into a kind of paste. A pile is then built of alternate strata, of wood and this paste, and being set fire to, the whole is again reduced to ashes. This process is repeated several times, till the ashes begin to clot and become hard : the most compact pieces being then selected, are packed up for sale without any fur-

ther preparation; the rest are lixiviated and boiled down to dryness, in the usual manner.

In some parts of Germany, potash is made from the empyreumatic acid, produced from wood, while burning into charcoal. By means of wide tubes of plate iron or copper, the acid and oil which would otherwise be dissipated in the air, are collected; the watery acid part being then separated from the other, is evaporated to dryness, and the residuum by calcination, affords an ash extremely rich in alkali.

Potash is converted into a much purer alkaline salt, called pearl-ash, by calcination: for this purpose, the potash broken into moderately small pieces, is spread on the floor of a reverberatory furnace, and being then kept red-hot, but not melted, for an hour or two, stirring it occasionally with an iron rake, all the carbonaceous and colouring particles are burnt out, and there remains behind, a dry porous and considerably caustic salt, extremely deliquescent, and from its bluish white colour called pearl-ash.

Dr. Percival has proposed the following method, for procuring pot-ash from the putrid water which runs from dung-hills; as being entitled to particular attention. His process is very simple: it consists in evaporating the fluid part, and in calcining the impure salt, till the foul or extraneous ingredients, are almost entirely dissipated by the fire. From 24 wine-pipes of such liquor, Dr. Percival obtained nine cwt. and 40 lbs. of saleable pot-ash, which was valued at 2l. 2s. per cwt.; the expense of the whole process, amounted to 4l. 9s. The salt thus procured, has a greyish-white appearance; and is, when broken, of a hard spongy texture: it is slightly affected by moist air; but, if it be kept in a dry apartment near the fire, a powder is formed on its surface. Lastly, this species of pot-ash contains, according to Dr. Percival's chemical analysis, such a proportion of pure alkali, as amounts to one-third part of its weight; while that imported from Russia, yields only one-eighth.

In the year 1796, a patent was granted to Mr. Hoakesly, for his method of making pot-ash; for the supply of all manufactures, in which the foreign salt or any alkaline matter is useful. The ingredients employed, consist of English, Welch, Irish, or Scotch kelp; foreign barilla; and the salts obtained from soap-boilers' waste, whether by evaporation, or by calcination. The materials are pulverized, and thrown into a furnace of a peculiar construction, where they are, by intense heat, melted into a liquid, which is discharged through a channel into pots.—When cold, the mass assumes the appearance of foreign pot-ash.

Several patents have been obtained in this country, for manufacturing potash, and for separating *sal polychist*, which is formed in the boiling of potash ley, owing to the presence of sulphat of potash in the liquor.

It has been thought of consequence in an economical point of view, to discover the proportion of potash afforded by different vegetables, and many analyses have been made for this purpose. They are however for the most part unsatisfactory, as they indicate only the quantity of soluble saline ingredients, without distinguishing the carbonated potash, from the sulphat and muriat of potash, with which it is always mixed. The most remarkable and interesting results, will be found in the following table, part of which were ascertained by a Committee of the Academy of Sciences at Paris, and the rest by the chemists whose names are subjoined. One hundred parts of each different species, being previously thoroughly dried, were burned by an open fire to ashes, which, after being weighed, were accurately lixiviated, till all their saline contents were extracted.

100 *parts*	*Ashes*	*Salt*	*Salt from 100 parts of Ashes*	
Fumitory	21.9	7.9	36.	Wiegleb
Wormwood	9.74	7.3	74.8	Ditto
Common Nettle . . .	10.67	2.5	23.4	Pertuis
Sow Thistle (Sonchus arvens.)	10.5	1.96	18.6	Ditto
Fern	5.	0.62	12.5	Ditto
Ditto	3.64	0.42	11.6	Home
Stalks of Maise , . .	8.86	1.75	19.7	
Ditto Sunflower . . .	5.72	2.	34.9	
Buckwheat . . .	.	. .	33.3	
Vine Branches . . .	3.4	0.55	16.2	
Heath . . .	.	. .	11.5	Wildenheim

100 *parts*	*Ashes*	*Salt*	*Salt from* 100 *parts of Ashes*	
Foxglove (digitalis purpurea)			33.	Leipsic econ. Soc.
Celandine (Chelidonium maj.)			25.	Ditto
Nightshade (atropa bellad.)			27.	Ditto
Boxwood	2.6	0.22	7.8	
Sallow	2.8	0.28	10.2	
Elm	2.3	0.39	16.6	
Oak	1.3	0.15	11.1	
Beche	0.58	0.12	21.9	
Aspen	1.22	0.07	6.1	
Fir	0.34	0.04	13.2	

Upon a cursory inspection of this table, it appears that the succulent herbaceous plants, afford a prodigiously greater proportion both of ashes and salt, than the shrubby and ligneous ones: it is however to be observed, that they were all reduced to a state of perfect dryness, before being weighed, a circumstance which will in a considerable degree, account for the apparently greater quantity of salt, contained in the succulent vegetables; for while the different kinds of wood, will not lose more than one-third, or even one-fifth of their weight in drying, fumitory will probably lose nine-tenths, or even more. It is not likely therefore, that it can ever be worth while, as some speculators have proposed, to be at the expense of cultivating fumitory and wormwood, for the sake of the potash, contained in their ashes.

It has been a subject of enquiry, among chemists, whether the pot-ash that is obtained by the combustion of vegetables, is formed by this process, or only disengaged by the decomposition of those acids, with which it was before united. The former of these opinions was adopted by Macquer, and many of the eminent chemists that were contemporary with him, but of late, the latter opinion, has been rather gaining ground. The principal arguments by which Macquer supports his theory are the following. 1st. When vegetables, capable of furnishing much alkali by combustion, are decomposed in any other way, no other saline products are obtained, but liquid and concrete acids. 2d. When vegetables are deprived of part of their acid by distillation, the produce of alkali is proportionately diminished. 3d. The concrete acids, as tartar, are changed into alkali, merely by combustion. 4th. Plants that yield little or no acid in distillation, are found after combustion, to afford little alkali. 5th. Plants, which when burnt without any previous alteration, yield much alkali, if burnt after undergoing complete putrefaction, afford no alkali.

In opposition, however, to these arguments it may be observed, 1st. That the native concrete, oxalic, and tartareous acids have been proved by modern chemists to be acidulæ, or in other words to contain potash, though not to full saturation of the acid; and therefore, when these are burnt, no conversion of acid into alkali takes place, but the acid being volatilized and decomposed, the alkali, which was before masked by an excess of acid, now exhibits itself with its usual characters. 2d. Nitre, completely formed, has been discovered in borage and some other vegetables, therefore the existence of potash, the alkaline base of this salt, is also necessarily demonstrated. 3d. Vauquelin has shown that the sap of trees contains acetite of potash. 4th. The reason why vegetables, after putrefaction, yield no alkali is, that their texture being broken up by this process, the water which drains through the mass dissolves and carries off all the alkali which they at first contained. This is manifest from the experiments of Mr. Birch, who, by evaporating and calcining 24 wine-pipes, or 3024 gallons, of dunghill water, procured 1048 lbs. of good marketable potash. We may, therefore, conclude that the potash obtained by lixiviation of vegetable ashes pre-existed in the plants themselves; whether this alkali is formed during the process of vegetation, or is only imbibed from the earth by the roots, is not as yet determined.

The varieties of pot and pearlash which are found in the market would, no doubt, on analysis afford very different results, especially with regard to the proportions of earthy matter, of water, and of carbonic acid; it is not, therefore, perhaps, much to be regretted, that we possess no very accurate analysis of any of them.

The only one on which any reliance can be placed, is of Dantzic pearlash by

Mr. Kirwan, in which are contained about

60.3	potash
22.4	carbonic acid
7.2	water
8.7	sulphated potash
0.7	muriated ditto
0.7	earth
100.0	

But if the analysis of any particular sample is of little consequence, generally speaking, yet it is of considerable importance both to the manufacturer and chemist, to be in possession of a compendious and accurate mode of ascertaining the contents of the various kinds of pot and pearlash, in order to make advantageous purchases of articles, in the intrinsic worth of which there is so much difference.

Mr. Kirwan's method of calculating the proportion of real alkali, in a given lixivium, from the quantity of precipitate which it throws down from a solution of alum, is by no means to be depended on; for, in the first place, the silex and alumine which the lixivium holds in solution, are precipitated together with the earth of alum; and, in the second place, so much depends on the degree of washing and calcination which the precipitate is made to undergo, that from equal quantities of alum it is scarcely possible to obtain equal weights of earth. Upon the whole, therefore, perhaps the best mode of proceeding is as follows.

1st. Prepare a diluted sulphuric acid by mixing the concentrated acid, called oil of vitriol, with three times its bulk of distilled water. Then test it by taking 100 grains of the diluted acid, and adding muriat of barytes as long as any precipitate falls down. The sulphat of barytes thus prepared, when washed with cold water, and dried at a low red heat, contains 33.3 per cent. of sulphuric acid; hence the real acid in any quantity of the diluted acid is readily ascertained.

2d. Pulverize 500 grains of the alkali under examination, and digest it in warm water, adding fresh portions of this fluid as long as any thing is dissolved. Then put all the solutions together, and drop in the tested sulphuric acid from a vial containing a known weight of the same, till the slightest possible excess of acid is indicated by a paper tinged with litmus. After this, heat the mixture to expel all the carbonic acid, and if the liquor changes turmeric paper, add a few drops more of sulphuric acid till it ceases to show an excess of alkali. Now weigh the vial of sulphuric acid, and thus ascertain how much has been expended in saturating the alkali, and for every 100 parts of real acid (as previously determined by muriat of barytes) thus employed, set down 121.2 of pure potash. The alkali being the part which gives value to the whole, this is all the examination which, in ordinary cases, is required; but, if the analysis is to be carried further,

3d. Take 500 grains more of the alkali, dissolve it in boiling water, and pour the solution into a flask; then place the flask and a vial containing from two to three ounces of pure nitric acid, into one scale of an accurate balance and equipose them. Afterwards add the acid, by degrees, to the alkali, as long as any effervescence takes place, and the loss of weight indicates the amount of carbonic acid. The solution will now, probably, crystallize; a sufficient quantity of water is, therefore, to be added, in order to dissolve the crystals, and nitrat of barytes is to be dropped in so long as any precipitate takes place. 100 parts of the dried sulphat of barytes thus procured, indicate 73.6 of sulphated potash. This being removed, add to the clear liquor nitrat of silver till it ceases to be decomposed. 100 parts of muriated silver show 41.34 of muriated potash. Thus the saline contents are all of them ascertained, viz. potash, carbonic acid, sulphat and muriat of potash. The earthy part is shown in the insoluble residue, No. 2, and in the precipitate which falls down on boiling the alkaline liquor after its saturation with sulphuric acid. If any sulphur is contained in the alkali, as is the case with the black potash, this will fall down, together with the earth, upon saturation with sulphuric acid, and is separated from the earth by a red heat.

Having now treated of the impure subcarbonats of potash, we shall conclude this article with an account of the purer subcarbonats, and the perfect carbonat of potash.

The most important of the purer subcarbonats is *salt of tartar*, which is prepared in the wine countries in considerable quantity, and is the kind generally used in medicine. The lees of wine, and the tartar that is deposited on the sides of the casks, are put into small bags about a foot long, and subjected to a strong pressure, in order to squeeze out all the wine, which is disposed of to the brandy distillers; the contents of the bags being carefully taken out, without breaking, form masses like loaves, which are dried in the sun, and then piled up in a furnace with alternate strata of charcoal. The fire being kindled, and the draft properly

regulated, the acid and inflammable matter of the tartar is burned off without fusing the alkaline part; when the process therefore is finished, the loaves remain of nearly the same size as before, but very porous, and perfectly white. Being then broken into pieces, they are dissolved in hot water, and the clear lixivium being evaporated to dryness, and slightly calcined, is fit for sale. Two and a half parts of tartar yield one of salt of tartar.

A more expeditious, but less economical, way of procuring salt of tartar, is to mix equal parts of crude tartar and nitre, and project the mixture into a red hot crucible. A rapid deflagration takes place, the nitric acid, and the combustible parts of the tartar mutually decompose each other, and there remains behind the alkaline base of each, united with some carbonic acid. This preparation is called *white flux, nitre fixed by tartar, extemporaneous potash.*

The perfectly saturated carbonat of potash has not been known to chemists longer than the time of Bergman. It may be prepared in two ways: the first, which was discovered by Berthollet, is as follows. Take equal parts of salt of tartar, and carbonat of ammonia, dissolve the whole in warm water, then pour the solution into a retort, and proceed to slow distillation; the potash having a stronger affinity for carbonic acid than ammonia has, deprives this latter of its acid, and in consequence, ammoniacal vapour is given out in great quantity: when this ceases, the contents of the retort are to be poured into a convenient vessel, where, by refrigeration, a copious deposition of crystallized carbonat of potash will take place.

The other method, and that which is generally practised, is to put a solution of salt of tartar into an apparatus for impregnating water with carbonic acid, and then to throw in this acid till the alkali is quite saturated, and refuses to take up any more; on opening the barrel, it will be found lined with large crystals of carbonated potash.

As alkaline salts are of great importance in the several arts, the proportion of ashes afforded by different vegetables, and that of alkali by each vegetable, has of late been accurately attended to. Kirwan has therefore presented the best authenticated results of the experiments made with this view.

One thousand lbs.	*lbs. of ashes.*	*lbs. of salt.*	
Stalks of Turkey wheat, or mais	88.6	17.5	
Sun-flowers -	57.2	20.	
Vine-branches -	34.	5.5	
Box - -	29.	2.26	
Sallow - -	28.	2.85	
Elm - -	23.5	3.9	
Oak - -	13.5	1.5	
Aspen - -	12.2	0.74	
Beech - -	5.8	1.27	
Fir - - -	3.4	0.45	
Fern, in August	36.46	4.25	Home
Wormwood -	97.44	73.	Wiegleb
Fumitory - -	219.	79.	Idem.

Table of the saline product of one thousand lbs. of ashes of the following vegetables.

	Saline products.
Stalks of Turkey wheat, or mais	198 lbs.
Stalks of Sun-flower	349
Vine branches	162.6
Elm - -	166
Box - -	78
Sallow - -	102
Oak - -	111
Aspen - -	61
Beech - -	219
Fir - -	132
Fern, cut in August	116 or 125 according to Wildenheim.
Wormwood -	748
Fumitory -	360
Heath - -	115 Wildenheim.

On these tables Kirwan makes the following remarks:

1. That, in general, weeds yield more ashes, and their ashes much more salt, than woods; and that consequently, as to salts of the vegetable alkali kind, as potash, pearlash, cashup, &c., neither America, Trieste, nor the northern countries, have any advantage over Ireland.

2. That of all weeds, fumitory produces most salt, and next to it wormwood. But if we attend only to the quantity of salt in a given weight of ashes, the ashes of wormwood contain most. Trifolium fibrinum also produces more ashes and salt than fern.

Most of the experiments on woods were made in France by order of government, under the inspection of the overseers of the saltpetre works; yet these are to be read with caution by those who attend to the quantity of alkali with respect to bleachers. For as sulphat of potash, a salt useless to bleachers, is as serviceable to the makers of saltpetre as alkaline salts, they have constantly confounded one with the other; but the experiments made on weeds were instituted by persons

who carefully discriminated these salts. [Much of the nitre obtained by elixation of the nitre-beds has a calcareous basis. Sulphat of potash will change this into nitre by double affinity, for the alkali unites with the nitric acid, which gives its calcareous base to the sulphuric.] One hundred grains of the salt of wormwood contain but six of the sulphat of potash, and one hundred grains of the salt of fumitory contain fifteen. All alkaline salts, unless mixed with lime, contain also one-fifth at least of carbonic acid, which produces no other effect in bleaching than that of restraining their activity.

The process for obtaining pot and pearl ash is given by Kirwan, as follows:

1. The weeds should be cut just before they seed, then spread, well dried, and gathered clean.

2. They should be burned within doors on a grate, and the ashes laid in a chest as fast as they are produced. If any charcoal be visible, it should be picked out, and thrown back into the fire. If the weeds be moist, much coal will be found. A close smothered fire, which has been recommended by some, is very prejudicial.

3. They should be lixiviated with twelve times their weight of boiling water. A drop of the solution of corrosive sublimate will immediately discover when the water ceases to take up any more alkali. The earthy matter that remains is said to be a good manure for clayey soils.

4. The ley thus formed should be evaporated to dryness in iron pans. Two or three at least of these should be used, and the ley, as fast as it is concreted, passed from the one to the other. Thus, much time is saved, as weak leys evaporate more quickly than the stronger. The salt thus procured is of a dark colour, and contains much extractive matter, and being formed in iron pots is called potash.

5. This salt should then be carried to a reverberatory furnace, in which the extractive matter is burnt off, and much of the water dissipated: hence it generally loses from ten to fifteen per cent. of its weight. Particular care should be taken to prevent its melting, as the extractive matter would not then be perfectly consumed, and the alkali would form such a union with the earthy parts as could not easily be dissolved. Kirwan adds this caution, because Dr. Lewis and Mr. Dossie have inadvertently directed the contrary. This salt, thus refined, is called pearlash, and must be the same as the Dantzic pearlash.

The French call the refined ash *potasse*, and the unrefined *salin*. Kirwan remarks, that the alkali manufactured in the above-mentioned manner may not be sufficiently pure for the earlier operations of bleaching; but by the addition of half a pound of quicklime to every hundred of the salt, or ten pounds for every ton, it will be rendered sufficiently sharp. There is no danger, that any of the lime will remain in the ley; but if any should, it will immediately be discovered and deposited by the addition of a little of the unmixed ley.

For the most economical construction of a laboratory and furnaces for the above operations, Kirwan refers to the description given in a French tract called *L'Art de fabriquer le Salin et la Potasse*, which I have not seen. And he adds, that it would be no inconsiderable advantage to perform the evaporation by a fire made of vegetables, the ashes of which might afterwards be employed. Pearlash, as he also remarks, is frequently tinged green or blue from manganese, which Scheele has shown to exist in the ashes of most vegetables. When the alkali is calcined without melting, it proves perfectly white, like the Dantzic pearlash.

To obtain this alkali pure, two parts of quicklime in powder are added to one of pearlash; as much water as will slake the lime is then poured on; and afterward more water is added, so as to reduce the whole to a thin consistence. After this has stood two or three days, stirring it occasionally, the liquor is filtered through a large glass funnel, the tube of which is obstructed by a piece of linen; and the residuum is elutriated on the filter with more water, till eight or ten times the weight of the pearlash have passed through. In this process, however, the whole of the carbonic acid is not extracted by the lime, other saline matters will be held in solution, and a portion of silex may be dissolved by means of the alkali. Barytes, however, will abstract the greater part of the carbonic acid, and likewise the sulphuric, as its attraction for these is more powerful than that of lime.

If it be required in a state of extreme purity, Berthollet recommends, to evaporate this solution till it becomes of a thickish consistence, add about an equal weight of alcohol, and let the mixture stand some time in a close vesel. Some solid matter, partly crystallized, will collect at the bottom; above this will be a small quantity of a dark coloured fluid; and on the top another, lighter. The latter, separated by decantation, is to be evaporated quickly in a silver basin in a sand heat. Glass, or almost any other metal, would be cor-

roded by the potash. Before the evaporation has been carried far, the solution is to be removed from the fire, and suffered to stand at rest; when it will again separate into two fluids. The lighter, being poured off, is again to be evaporated with a quick heat; and on standing a day or two in a close vessel it will deposit transparent crystals of pure potash. If the liquor be evaporated to a pellicle, the potash will concrete, without regular crystallization. In both cases a high coloured liquor is separated, which is to be poured off; and the potash must be kept carefully secluded from air.

Mr. Henry observes, that a perfectly pure solution of potash will remain transparent on the addition of barytic water, show no effervescence with dilute sulphuric acid, and not give any precipitate on blowing air from the lungs through it by means of a tube.

Mr. Kirwan examined the Dantzic pearl ash. It is exceedingly white, and if not exposed to the air very hard. Its taste is alkaline. The contents of various specimens were different, but at a medium he found the pound troy to consist of

Carbonic acid -	1290 grains
Moisture - -	414
Sulphat of potash -	505
Muriat of potash -	36
Earth - -	38
Potash -	3477
	5760

As the examination of the alkalies of commerce must be of great utility to the manufacturer, but is very tedious in the way of solution and evaporation, Mr. Kirwan proposes a test by the precipitation of the earth from alum, by a solution of these salts.

To discover whether any quantity of fixed alkali worth attention exist in any saline compound, dissolve one ounce of it in boiling water, and into this solution let fall a drop of the solution of corrosive sublimate. This will be converted into a brick colour if an alkali be present, or into a brick colour mixed with yellow if the substance contained lime.

But the substance used by bleachers being always impregnated by an alkali, the above trial is in general superfluous, except for the purpose of detecting lime. The quantity of alkali is therefore what they should chiefly be solicitous to determine: and for this purpose,

1. Procure a quantity of alum, suppose one pound, reduce it to powder, wash it in cold water, and then put it into a teapot, pouring on it three or four times its weight of boiling water.

2. Weigh an ounce of the ash or alkaline substance to be tried, powder it, and put it into a Florence flask with one pound of pure water (common water boiled for a quarter of an hour, and afterwards filtered through paper, will answer) if the saline substance to be examined be of the nature of barilla or potashes, or half a pound of water if it contain but little earthy matter or pearlash. Let them boil for a quarter of an hour; when cool, let the solution be filtered into another Florence flask.

3. This being done, gradually pour this solution of alum hot into the alkaline solution also heated. A precipitation will immediately appear. Shake them well together, and let the effervescence, if any, cease before more of the aluminous solution be added. Continue the addition of the alum until the mixed liquor, when clear, turns syrup of violets, or paper tinged blue by radishes, or by litmus, red. Then pour the liquor and precipitate on a paper filter placed in a brass funnel, and the precipitated earth will remain on the filter. Pour on this a pound or more of hot water gradually, until it becomes tasteless. Take up the filter, and let the earth dry in it until they separate easily. Then put the earth into a cup of Staffordshire ware, place it on hot sand, and dry the earth until it no longer adheres either to glass or iron; then reduce it to powder in the cup with the glass pestle, and keep it a quarter of an hour in a heat from 470° to 500°.

4. The earth being thus dried, throw it into a Florence cask, and weigh it; then put about an ounce of muriatic acid into another flask, and place this in the same scale as the earth, and counterbalance both in the opposite scale: this being done, pour the acid gradually into the flask that contains the earth; and when all effervescence is over (if there be any) blow into the flask, and observe what weight must be added to the scale containing the flasks to restore the equilibrium; subtract this weight from that of the earth, the remainder is a weight exactly proportioned to the weight of mere alkali of that particular species which is contained in one ounce of the substance examined; all besides is superfluous matter.

Kirwan remarks, that alkalies of the same species may thus be directly compared, because alkalies of different species cannot but require the intervention of another proportion; and the reason he gives is, because equal quantities of alka-

lies of different species precipitate unequal quantities of earth of alum. Thus 100 parts by weight of mere potash precipitate 78 of earth of alum; but 100 parts of soda precipitate 170.8 parts of that earth. Therefore the precipitation of 78 parts of earth of alum by potash, denotes as much of this as the precipitation of 170.8 of that earth by the soda denotes of the soda. Hence the quantities of alkali in all the different species of potashes, pearl-ashes, weed or wood-ashes, may be immediately compared by the above test, as they all contain the potash; and the different kinds of kelp or kelps manufactured in different places, and the different sorts of barilla, may be thus compared, because they all contain the soda; but kelps and pot-ashes, as they contain different sorts of alkali, can only be compared together by means of the proportion above indicated.

The application of this test is founded on the following principles:

1. That a hot solution of a free alkali, or of an alkali combined only with carbonic acid or sulphur, can hold no terrene or metallico-neutral salt in solution; though it may alkalino-neutral salt or quick-lime, if the alkali be free from carbonic acid.

2. That earth of alum cannot be precipitated either totally or partially by the hot solutions of any alkalino-neutral salt, and therefore that its precipitation is always due to the presence of a free alkali, or at least of an alkali combined only with carbonic acid or sulphur, to the quantity of which it is always proportional. It is true, quick-lime will also decompose alum; but the presence of quick-lime is easily discovered, by the addition of a few drops of any mild alkaline solution, and by the same means as easily separated.

3. That if the earth of alum, take up carbonic acid (which would increase its weight,) this air will be separated by the heat employed in drying it, or at least by the muriatic acid poured upon it.

Kirwan says, he can see but one inaccuracy attending this test, and that of little moment; it is this, if the alkali contain sulphur this will also be precipitated with the earth of alum, and increase its weight. The limits of this inaccuracy, at least in common cases, scarcely reach two or three grains.

Sulphur is easily detected in an alkaline solution, by saturating it with an acid; sulphuretted hydrogen is generally developed, and the liquor becomes troubled.

Not only the proportion, but also the absolute weight of alkali in different alkaline substances or ashes, may be found by this test. Attention must be paid to the nature of the alkali, and the quantity of earth, a determinate portion will throw down; which must be ascertained as to the first by experiment, and as to the latter by fundamental trials. The reader may consult an essay by Dr. Higgins, on the same subject.

Mr. Davy has made an extraordinary discovery, by subjecting potash and soda, to the action of a powerful galvanic pile. Moistened potash, exposed on a plate of platina, to the action of the galvanic circle, was decomposed into oxygen and a base, that in some of its properties resembles the metals. This detrudes oxygen from its rank, as the generator of acidity, since it appears to be a constituent part of both, the fixed alkalies, and the volatile alkalies likewise, and consequently to be no less essential to alkalies, than to acids; if not more essential to them, since we know of some substances possessing acid properties, the existence of oxygen in which is at least very doubtful, if not disproved. This experiment has been confirmed by other chemists.

The base of potash thus obtained is highly inflammable, and forms an amalgam with mercury: but it is so far from having the specific gravity of metals, that it is lighter than most fluids, its gravity being to that of distilled water, only as six to ten.

At the freezing point it is hard, brittle, and when broken exhibits facets, as if crystallized, when examined by the microscope. At 40° it is scarcely distinguishable from a small globule of quicksilver; at 60° it is quite fluid; and at a heat little below redness, it is volatile.

It is extremely greedy of oxygen, absorbing it rapidly from the atmosphere, and resuming the alkaline state. If amalgamated with twice its bulk of quicksilver, and applied to iron, silver, gold or platina, these metals are immediately dissolved, and converted into oxydes, while the alkali is regenerated. Glass is decomposed by it, the basis of potash combining with its alkali, and forming a red oxyde, in which the base is less oxygenated than in potash. This red oxyde, was likewise procured by other means.

From a considerable number of experiments, potash appeared to consist of 85 parts base, and 15 of oxygen.

A globule of the base, placed on a piece of ice, burnt with a bright flame, and intense heat, and potash was found in the water, from the melted ice. In this case as well as when a globule was thrown into water, a considerable quantity of

hydrogen was rapidly evolved. When a globule was placed on a piece of moist turmeric paper, it appeared instantly to acquire intense heat, but moved so rapidly in quest of the moisture, that the paper was no where burned; but a deep red stain, that marked its course, proved the regeneration of the alkali.

From the avidity of the metalloid (as it has been called) for oxigen, it is not easy to keep it: but in distilled naphtha a film forms round it, which excludes oxigen so that it may be preserved four or five days.

Mr. Charles Sylvester, and some other gentlemen, have repeated Mr. Davy's experiments with similar results. Mr. Sylvester, however, always found a small portion of black matter formed at the wire coming from the copper end of the battery, which was not a suboxide of the base, for it remained permanent in water several weeks; and it did not appear to be charcoal. In one of this gentleman's experiments, the metalloid exploded, and burst the glass tube in which it was enclosed; and in one by a gentleman at Tunbridge, it deflagrated suddenly, and was thrown about so as to injure his eyes: it should not be attempted, therefore, without caution.

Potash forms a considerable branch of manufacture in the United States; the quantity annually made is sufficient for home supply, and for foreign markets.

POTASSIUM.---The base of potash, a peculiar metal. See POTASH.

POTATOE STARCH. See STARCH.

POTATOE, *various uses of*.---Besides starch, potatoes will afford saccharine matter, and properly prepared will yield spirit by distillation, which will be noticed hereafter.

A fine *size* may be prepared from potatoes, which will answer all the purposes of that in common use, particularly for whitening cielings and walls. With this intention, any quantity of newly-made potatoe-starch should be boiled into a paste; a sufficient portion of which ought to be mixed with the whiteing, after the latter has been diluted with water. The coat thus prepared is much clearer; retains its whiteness longer; and is less liable to crack or scale, than such as is mixed with animal glue....There is another economical way of employing the water expressed from potatoes in the processes of making starch or size. This liquor is useful for washing linen, whether plain or coloured, silk handkerchiefs, stockings, &c. without the aid of any ley or soap: it is said to improve rather than to diminish the tint, while it restores their original brightness, and imparts a degree of stiffness to silk stuffs, which cannot be obtained by the common method of cleaning them. It deserves, however, to be remarked, that no discoloured or otherwise damaged roots must be used for this purpose....Bakers convert the pulp of potatoes into *yeast*, by adding a small proportion (about the 8th or 10th part) of the latter, together with two drachms of calcined and pulverized crabs'-claws or oyster-shells, and a similar quantity of burnt hartshorn, to every pailful of the preparation. This compound is asserted to increase the bulk of the paste, and consequently of the bread; but double the measure of it is required to serve as a complete substitute for barm.

Farther, the stalks of these roots, when cut in small pieces, afford a grateful food to cattle: the haulm has also been converted into paper; but it is more generally, and, we conceive, more profitably, employed for stable-litter; or, when straw is scarce, instead of thatch for cottages.... Lastly, even the *potatoes* may be usefully employed in domestic economy. In the *New Swedish Journal of Agriculture* for 1796, it is directed, that such potatoes should be collected while in a green and hard state; then well rinsed in cold water, and put for 48 hours into a strong filtrated brine. Next, they are to be placed for six or eight hours in a colander or drain, when they ought to be boiled in good vinegar, with the addition of some spice, till they acquire a certain degree of transparency, without becoming soft. Thus prepared, they will afford a more palatable and less hurtful pickle than either olives or cucumbers.

The potatoe is one of the most valuable roots for culinary uses: when boiled, it forms a principal article of food, and serves partly as a substitute for bread. Mixed with wheaten flour, fermented with yeast, and properly baked, it makes a wholesome and nutritious loaf: the most economical method of preparing these roots, we have already stated.

M. Baume, of France, has invented a very convenient machine for the purpose of grinding potatoes to make starch, or to obtain flour from them; a plate of which may be seen in the *Repertory of Arts*, or in the volume on potatoes, published by the British Board of Agriculture. To those who wish to pursue the grinding potatoes as a business, the machine will be found highly advantageous. For domestic purposes, a large grater will be sufficient.

Mr. Biddis obtained a patent from the United States for the manufacture of potatoe starch.

POTTER'S LEAD ORE. See LEAD.

POTTERY.—The art of making pottery is intimately connected with chemistry, not only from the great use made of earthen vessels by chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry. We must however acknowledge, that, although chemists have the greatest interest to procure good crucibles and other earthen vessels, this art has been left almost entirely to the potter. Mr. Pott is the first who attended to this object. Beside many experiments stated in his Lithogeognosia, from which much instruction may be received relating to the perfection of chemical vessels, he has written a treatise expressly on this subject, in which he gives many compositions for crucibles, the chief of which shall be mentioned in this article.

All kinds of pottery are in general made of clays or argillaceous earths, because these earths are capable of being kneaded, and easily receiving any form, and of acquiring much solidity and hardness by exposure to fire. But clays differ much in the effects produced upon them by fire. Some clays which are of the purest kind resist the most violent fire without receiving any other change than a considerable hardness; but still they are not rendered so hard and compact as other clays. A second kind of clays by exposure to violent heat acquires a hardness equal to that of flints, and a texture compact and glossy, like that of good porcelain; but they are nevertheless infusible by the most violent heat. These qualities are occasioned by some fusible materials being mixed with them, as sand, chalk, gypsum, or ferruginous earth, which are in too small a quantity to effect a complete, but only a beginning or partial fusion. Lastly, a third kind of clays is first hardened by fire, and afterward completely fused. This last kind of clays evidently contains the largest quantity of the fusible matters above mentioned.

From the properties of these three principal clays it may be concluded, that from clays alone three principal kinds of pottery may be produced. With the first kind of clay, pots or crucibles may be formed capable of sustaining the most violent fire without fusion, of containing melted metals, and even hard glasses not too fluid; but which, from want of sufficient compactness, are incapable of containing during a long time in fusion very fusible substances, such as nitre, glass of lead, glasses containing much arsenic, &c. by which substances their pores are pervaded. These clays are employed advantageously for the formation of large pots or crucibles used in glass-houses, and for containing hard glass, as bottle-glass, &c.

With clays of the second kind may be made crucibles and other potteries, commonly called stone ware. Potteries made with these earths, when sufficiently baked, are very sonorous, so hard as to strike fire with steel, capable of containing all liquids, of which the former kind, from their porosity, are incapable, and even resist the action of nitre, glass of lead, and other fluxes, when the earth of which they are formed is of good quality: but their hardness and density, which prevent their sudden expansion and contraction, by the hasty application of heat and cold, make them liable to break in all operations where they are suddenly exposed to heat or to cold, as for instance, in a furnace through which a strong current of air passes. If this kind of pottery had not this inconvenience, it would be the best and most perfect for the purposes of ordinary life and chemistry. Notwithstanding this inconvenience, it is the only pottery that is applicable on many occasions; but then all possible care must be taken to prevent its breaking, by a very gradual application of heat and cold, and by protecting it from currents of cold air.

With the fusible clays may be made many kinds of vessels, which are cheap, as they require little fire to bake them; for all this kind of pottery is but slightly baked; whence its texture is coarse and porous. Some utensils are made of this pottery without glazing; but in general they are covered with a glazing, without which, water or other liquids would pass through their pores. Some of this pottery, which is finished with more care, is covered with a white enamel, which makes it very neat and like porcelain. This is called DELFT WARE. This is a kind of pottery made at Delft, in Holland, which formerly supplied all Europe, until it was supplanted by a yellow pottery made in France, which has since given place to the queen's ware, and various kinds of china fabricated in Great Britain.

Pottery may be distinguished into two kinds; namely, that which has a transparent varnish or glaze, and that which has an opake glaze. The queen's ware, the stone ware, and various kinds of china, are of the former sort. The Delft ware and other kinds of china ware are of the latter kind. In every kind of pottery it is an object of great importance, that the

expansions and contractions of the glaze and the body should be nearly the same at like temperatures: but this desirable property is seldom found in vessels covered with an opake glaze or enamel.

As the Delft pottery has fallen into disuse, it seems of less consequence to inquire into its composition, more especially as this disuse has been occasioned by the production of better potteries. Other coarser potteries of this kind are glazed with glass of lead mixed with metallic oxides, or fusible coloured earths; from which they receive various colours. This is the ordinary pottery.

A fine kind of pottery is made of white clays, or of such as whiten in the fire, the surface of which is vitrified by throwing into the furnace, when the ware is sufficiently baked, some common salt and saltpetre. This pottery is called English ware on the continent, because the first and best was made in England. It is white, fine, well baked, and has some small degree of transparency when thin; so that it is intermediate betwixt porcelain and common stone-ware, and may therefore be called a semiporcelain.

Keir affirms, that he has never seen any English stone-ware, that had the semi-transparency and whiteness, mentioned by Macquer. As the English stone-ware is composed of tobacco-pipe clay, and ground flints, both which substances are perfectly infusible, singly or jointly, it cannot possess any degree of transparency. The use of the flints, is to give strength to the ware, so as it shall preserve its form, during the baking: whereas vessels made of clay alone, though infusible by fire, and capable of acquiring, by having been exposed to an intense heat, the hardness of the best porcelain: yet while they are hot and soft, they sink by their own weight, so as to lose the form given them. The process of manufacturing this stone-ware, according to Dr. Watson, is as follows:

Tobacco-pipe clay from Dorcetshire, England, is beaten much in water: by this process, the finer parts of the clay remain suspended in the water, while the coarser sand and other impurities, fall to the bottom The thick liquid, consisting of water and the finer parts of the clay, is farther purified, by passing it through hair and lawn sieves, of different degrees of fineness. After this, the liquid is mixed (in various proportions for various wares) with another liquor, of as nearly, as may be the same density, and consisting of flints calcined, ground and suspended in water. The mixture is then dried in a kiln; and being afterwards beaten to a proper temper, it becomes fit for being formed at the wheel into dishes, plates, bowls, &c. When the ware is to be put into the furnace to be baked, the several pieces of it are placed in the cases made of clay, called seggars, which are piled one upon another, in the dome of the furnace: a fire is then lighted; and when the ware is brought to a temper, which happens in about 48 hours, it is glazed by common salt. The salt is thrown into the furnace, through holes in the upper part of it, by the heat of which it is instantly converted into a thick vapour; which circulating through the furnace, enters the seggar through holes made in its side (the top being covered, to prevent the salt from falling on the ware,) and attaching itself to the surface of the ware, it forms that vitreous coat upon the surface, which is called its glaze.

This curious method of glazing earthen ware, by the vapour of common salt was introduced into England by two Dutchmen, near a century ago. It appears to be produced by a combination of the alkali, with the siliceous earth or sand of the clay..

The yellow or queen's ware, is made of the same materials as the flint-ware; but the proportion in which the materials are mixed is not the same, nor is the ware glazed in the same way. The flint-ware is generally made of four measures of liquid flint, and of eighteen of liquid clay; the yellow ware has a greater proportion of clay in it; in some manufactories they mix twenty, and in others, twenty-four measures of clay with four of flint. These proportions, if estimated by the weight of the materials, would probably give for the flint-ware about three cwt. of clay to one cwt. of flint, and for the yellow ware somewhat more clay. The proportion, however, for both sorts of ware depends very much upon the nature of the clay, which is very variable even in the same pit. Hence a previous trial must be made of the quality of the clay, by burning a kiln of the ware. If there be too much flint mixed with the clay, the ware, when exposed to the air after burning, is apt to crack; and if there be too little, the ware will not receive the proper glaze, from the circulation of the salt vapour.

This glaze, even when it is most perfect, is in appearance less beautiful, than the glaze on the yellow ware.

The yellow glaze is made, by mixing together in water, till it becomes as thick as cream, 112 lb. of white lead, 24 lb. of ground flint, and 6 lb. of ground flint glass, and mix only 80 lb. of white lead with 20 lb. of ground flint; and others, doubt-

less observe different rules, of which it is very difficult to obtain an account.

The ware before it is glazed, is baked, in the fire: by this means it acquires the property of strongly imbibing moisture; it is therefore dipped in the liquid glaze, and suddenly taken out; the glaze is imbibed into its pores, and the ware presently becomes dry. It is then exposed a second time to the fire, by which means the glaze that it has imbibed is melted, and a thin glassy coat is formed upon its surface: the colour of this coat, is more or less yellow, according as a greater or less proportion of lead has been used. The lead is principally instrumental in producing the glaze, as well as in giving it the yellow colour; for lead, of all the substances hitherto known, has the greatest power of promoting the vitrification of the substances, with which it is mixed. The flint serves to give a consistence to the lead, during the time of its vitrification, and to hinder it from becoming too fluid, and running down the sides of the ware, and thereby leaving them unglazed.

The yellowish colour which lead gives when vitrified with flints, may be wholly changed by very small additions, of other mineral substances. Thus, to give one instance; the beautiful black glaze, which is fixed on one sort of the ware, made at Nottingham, is composed of twenty-one parts, by weight of white lead, of five of powdered flints, and of three of manganese. The queen's ware at present made, is much whiter than formerly.

The coarse stone-ware made at Bristol, consists of tobacco-pipe clay and sand, and is glazed by the vapour of salt, like Staffordshire flint-ware; but it is far inferior to it in beauty.

Chaptal tried various methods to glaze pottery without lead, and two among them succeeded, well enough in his opinion, to justify his publishing them. The first, consists in mixing the earth of Murviel, which appears to be a fusible or compound clay, in water, and dipping the pottery therein: this done it is suffered to dry; after which it is plunged into a second water, in which levigated green glass is mixed. This covering of vitreous powder fuses with the clay of Murveil, and the result is very smooth, very white, and very cheap glazing.

The second method consists in immersing the dried pottery, into a strong solution of sea-salt, and afterwards baking it. The trial which Chaptal made in his furnaces gave him reason to expect, that this method might be used in large works.

He likewise obtained a very black glazing, by exposing pottery, strongly heated to the fumes of sea-coal. He coated several vessels in this manner, by throwing a large quantity of coal in powder into a furnace, wherein the pottery was ignited to whiteness. The effect, he informs us, is still more complete, when the chimneys or tubes, of aspiration of the furnace are at that moment closed, and kept so for some minutes.

The residuum left after distilling oxygenized muriatic acid, ground with sand, would make a good dark-bronze-coloured glaze, free from the noxious qualities imputable to lead.

Mr. Jousselin, a French potter, says, that he employs a glaze, composed entirely of earthy materials, which does not cost more than one-fifteenth of the price, of what is commonly used. And the pumice-stone affords a glaze, that contains nothing in the least noxious, and on which no menstruum known, has the least effect.

A writer in Sonnini's Bibliothèque Physico économique observes, that it is of some importance in domestic economy, to be able to judge of the goodness of an article in such extensive use as earthen ware, with regard to the goodness and innoxiousness of its coating.

The glaze of earthen ware, may have several defects: it may be scratched more or less readily by a hard body; weak acids, such as vinegar, lemon-juice, verjuice, &c., may attack and dissolve the lead it contains; or oily substances standing long on it, may produce the same effect, stain it and render it dull.

To determine its power of resisting friction, it may be rubbed with sand; and if this scratch it more readily than it does a glaze, known to be good, we may be assured it is soft.

If vinegar be boiled for some hours, in a vessel coated with a soft glaze, it will attack the glaze, and dissolve a portion of its lead, which will be precipitated from the vinegar, on the addition of a few drops of sulphuric acid, commonly called oil of vitriol.

But a method more within every one's reach, and therefore deserving to be known, is to let fall a drop of strong ink, on a piece of earthen ware, dry it before the fire, and then wash it. If the glaze be too soft, the ink will leave on it a slight spot.

Some potteries can sustain a sudden application of heat and cold, sufficiently well for the uses of the kitchen, and are always the coarsest, least baked, and the glazing of which is the softest. They also do not last long, when much used;

for it is absurd to suppose, as some persons do, that pottery may be made capable of sustaining fire like a metal vessel. We are certain, that the best of this kind, which are employed for this purpose, break as soon as they are put upon the fire. They do not indeed break so as to separate in pieces, or even to let liquors pass through them: but many small cracks which may be perceived in their glazing, and by their ceasing to ring when struck, after they have been once heated. Each time that these vessels are set on the fire, many small and imperceptible cracks are formed in them, which by frequent use, become so numerous, that the vessel may be broken by the least force. Thus all the difference betwixt the potteries, which are intended to be used on the fire, and the good stone-ware which is not intended for that purpose, is, that the latter kind may be broken at once, when heated and cooled carelessly, whereas the former is broken by degrees. Nevertheless the fire-ware is useful, as it can serve for a short time.

Tobacco-pipes require a very fine, tenacious, and refractory clay, which is either naturally of a perfectly white colour, or, if it had somewhat of a gray cast, will necessartly burn white. A clay of this kind, must absolutely contain no calcareous or ferruginous earth, and must likewise be carefully deprived of any sand, it may contain by washing. It ought to possess, besides, the capital property shrinking but little in the fire. If it should not prove sufficiently ductile, it may be meliorated, by the admixture of another sort. Last of all, it is beaten, kneaded, ground, washed, and sifted, till it acquires the requisite degree of fineness and ductility.

When after this preparation, the clay has obtained a due degree of ductility, it is rolled out in small portions, to the usual length of a pipe, perforated with a wire, and put together with the wire, into a brass mould, rubbed over with oil, to give it its external form; after which it is fixed in a vice, and the hollow part of the head formed with a stopper. The pipes thus brought into form, are cleared of the redundant clay that adheres to the seams, they are then marked with an iron stamp upon the heel, and their surfaces smoothed and polished. When they are well dried, they are put into boxes, and baked in a furnace.

In the Dutch manufactories, these boxes consist of conical pots made of clay, with conical lids, with a tube passing through the middle of them, by which the pipes are supported; or else they are long clay boxes, in which the pipes are laid horizontally, and stratified with fragments of pipes pounded small.

Lastly, the pipes when baked, should be covered with a glazing or varnish, and afterwards rubbed with a cloth. This glazing consists of a quarter of a pound of soap, two ounces of white wax, and one ounce of gum arabic or tragacanth, which are all boiled together, in five pints of water for the space of a few minutes.

Under the article *Glass*, we have treated on the fusibility of earthy mixtures, to which therefore we shall refer our readers. PORCELAIN may be defined to be a species of pottery ware composed of an earthy mixture which resists complete fusion in a very considerable heat, but has been brought by a less heat than its melting point to a state of incipient fusion, and thereby acquired extreme hardness, sonorousness, semitransparency, and a semiconchoidal splintery fracture, approaching to the vitreous which is completely conchoidal. This last is quite a distinctive character betwcen porcelain and pottery, for the fracture of the latter is simply granular. It appears probable, therefore, that no chemical action takes place in any pottery mixture till it arrives at the state of porcelain. The most perfect and beautiful porcelains of Japan and China are composed (as appears from the best testimony) of one earth in which silex predominates, and which melts in a strong fire, and of another which is infusible *per se*, and by an union of these alone (as it appears) a porcelain is produced which scarcely vitrifies at the utmost furnace heat which art can produce. This substance has the united excellencies of being very hard, of a beautiful semi-transparence, very white where not artificially coloured, very tough and cohesive, so that it has strength enough for the purposes for which it is designed when made very thin, and it bears sudden heating and cooling without cracking.

Of the beautiful European porcelains which have been made in imitation of the oriental, it should seem that none of them precisely unites all its distinguishing qualities. Earthy mixtures have been made equally strong, tough, and infusible, and as truly porcellanous when burnt, but these have not exactly equalled the best Japanese, in delicate whiteness and lustre. But as the latter are the most essential qualities, that of infusibility has been in general sacrificed, (which indeed is of no consequence for any of the common uses of porcelain) and therefore those that come up to the oriental in beauty and de-

licacy, of which there are several manufactures in different parts of Europe, for the most part soften and melt down in the most intense heat of a wind-furnace, at which the true Nankin and Japanese undergo no change.

Porcelain, if not properly annealed, is extremely brittle, and liable to crack: to prevent such accidents, it ought to be well boiled in pure water, before it is used; and, when cold, no hot fluid should be put into it, unless there be some sugar, or a tea-spoon in the vessel. Another method of obviating casualties, is that of holding china-vessels over steam, immediately before tea or coffee is poured into them. Accidents, however, often deface the beauty, or otherwise diminish the value of a *set of china:* hence, it becomes a desirable object to join or cement the fragments, so as to be imperceptible to the naked eye. Under the article CEMENT, we have stated the most proper expedients for this purpose.

The manufacture of the ordinary pottery is on the whole very simple, where the due selection of materials is made, but it is the more delicate ornamental part, the modelling, enamelling, painting, gilding, &c. which displays so much exquisite beauty, and which requires a combination of perseverance, skill, and practical nicety of management, that is hardly equalled in any other chemical manufacture.

The intimate mixture of the ingredients used in pottery, is of great importance to the beauty, compactness, and soundness of the ware. Formerly the wet clay and ground flint (or whatever was the other material) were beaten together with great and long-continued manual labour, no more water being added than was necessary to render the clay thoroughly plastic. This laborious (and therefore expensive) method has now been laid aside in the larger potteries, and the ingenious way has been substituted of bringing each material first to an impalpable powder, and diffusing them separately in as much water as will bring them to the consistence of thick cream, mixing them in due proportion by measure, and when thoroughly stirred together, evaporating the superfluous water till the mass is brought to a due consistence for working.

The following is the common process used in Staffordshire for making the ordinary ware. The materials are a fine clay brought chiefly from Devonshire, and a siliceous stone called *Chert*, or else common flint reduced to powder by heating red hot, quenching in water, and then grinding by wind-mills to a subtle powder. Each material is passed through fine brass sieves, then diffused in water, mixed by measure, and brought to a plastic state in the way just mentioned. A lump of this is then thrown on the potter's wheel, and by the workman's hands assisted by a small blunt iron knife-blade it is fashioned into the shape required, when circular, such as cups, saucers, plates, &c. but when made oval, or to any pattern form, it is moulded on a plaister model. Handles and spouts are then stuck on, if required, and the piece, after being again smoothed and the shape more accurately touched up, is set to dry for some days in a warm room, where it becomes so hard as to bear handling without altering its shape. When dry enough, it is enclosed along with many others in baked clay cases of the shape of band-boxes, called *seggars*, which are made of the coarse clays of the country. These are next ranged in the kiln or furnace so as to fill it, except a space in the middle for the fuel. Here the ware is baked till it has remained fully red-hot for a considerable time, which in the larger kilns consumes 10 or 15 tons of coal, after which the fire is allowed to go out, and when all is cooled, the seggars are taken out and their contents unpacked. The entire contents of one kiln will sometimes exceed 30,000 different pieces of pottery. The ware is then in the state of *biscuit;* it is perfect pottery, very hard, beautifully white with a slight shade of yellow, and of a smooth surface, quite void of gloss, much resembling a clean egg-shell.

The next process is the glazing, which is performed on all pottery intended for domestic use. For this purpose the biscuit ware is dipped in a tub containing a mixture of about 60 parts of litharge, 10 of clay, and 20 of ground flint, diffused in water to a creamy consistence, and when taken out enough adheres to the piece to give an uniform glazing when again heated. The pieces are then again packed up in the seggars, with small bits of pottery interposed between each, and fixed in a kiln as before. The glazing mixture fuses at a very moderate heat, and gives an uniform glossy coating, which finishes the process when it is intended for the common white ware. But the painting and gilding, each, require separate processes.

Something may be added in this place on the pottery employed in chemical operations. Formerly, when chemists made their own crucibles, muffles, &c. this was a very important brach of practical know-

ledge to every chemist, but at present this is almost wholly confined to the manufacturer, and we are only able to point out some of the leading circumstances which determine the goodness of pottery ware for one or other purpose.

Some very eminent chemists, among whom we may enumerate Glauber, Agricola, and Pott, have paid particular attention to this subject, and that enlightened manufacturer, the late Mr. Wedgewood, has introduced a species of ware which answers some important purposes better than any hitherto invented.

Three important requisites are demanded to constitute a perfect pottery for all chemical purposes, namely, infusibility at any heat; compactness of texture so as to retain saline and other fluxes in fusion without being materially acted on by them, or allowing them to transpire; and endurance of sudden changes of temperature, particularly sudden heating, without cracking or giving way in any degree.

These three requisites, however, have been found impracticable to be united in the same ware, which has led to the necessity of selecting the species of ware according to the intended use.

It is of considerable importance in all fire-vessels, that they should be able to bear heating and cooling with tolerable quickness, but it unfortunately happens that some of the most perfect ware in every other respect, is very deficient in this, and will even hardly bear the draught and flame of a wind furnace, however slowly heated, without danger of cracking. This is particularly the case with the valuable porcelain fire-ware invented by Mr. Wedgewood. This property of cracking on sudden changes of temperature, appears particularly to depend on the two circumstances of hardness and closeness of texture, and the latter is the greatest (ceteris paribus) in proportion to the fineness of division of the materials before burning. Thus in the ware just mentioned, both the clay and flint are brought to a most impalpable powder before mixture, and the texture is uncommonly hard and close; and on the other hand, it has been found necessary in making the best Hessian and other crucibles, to separate and *reject* the finer part of the siliceous ingredient, for the express purpose of enabling it to bear the strong draught of the wind furnace. The Wedgewood ware stands sudden heating and cooling better when it is covered with a thin coating of Windsor loam, or of a a fire-lute composed of clay and coarse sand, and tow or horse-dung.

Of the earthen vessels intended to hold acid or corrosive liquors in distillation, no ware is so perfect as the white Wedgewood porcelain ware already mentioned, its texture being so close as not to require any lead-glazing. The only defect of this is the danger of cracking on any sudden change of temperature.

All the operations where great heat is employed, require vessels of baked earth; because these alone can sustain at once the action of violent fire and of chemical solvents. Vessels made of good baked clay eminently possess these two qualities, and are the best which can be employed in chemistry; but as they have the inconvenience of breaking by sudden application of heat and cold, and as many operations do not require vessels so dense, mixtures of earth have been used, of which crucibles are made, capable of being rendered suddenly red hot, and suddenly cooled without breaking, and sufficiently dense to contain metals and other matters in fusion during a long time. The best crucibles of this kind are brought from Hesse in Germany. These crucibles are made with a good refractory clay, mixed, according to Pott, with two parts of sand of a middling fineness, from which the finest part has been sifted. The mixture of sand with clay produces two good effects; the first, to make the clay leaner, as it is called, and thus to prevent the clay from cracking by the contraction it sustains during its drying; and secondly, to prevent its acquiring too great closeness and compactness of texture by being baked. Thus we obtain crucibles moderately dense, capable of containing metals and other things in fusion, and infinitely less subject to break by heat and cold than those made of pure clay.

The particles of the sand mixed with clay in this composition for crucibles, ought to be rather of a moderate size, than very fine; because, as Pott remarks, the former render the crucibles much less apt to crack than the latter. In the second place, that chemist forbids the use of sand, flints, or other earths of that kind, in the composition of crucibles intended to contain glasses, or other vitrifying matters, a long time in fusion; because these vitreous matters act upon sand, flints, and all those called vitrifiable earths, by which means these crucibles are soon penetrated and melted.

This inconvenience is prevented, and all the advantages obtained from a mixture of sand are procured, by substituting to the sand a good baked clay in gross powder. In this manner are made the pots which contain the vitrifiable mate-

rials in glas-house furnaces, some of which resist the continued fires employed there during three weeks or a month. The pots indeed used in glass-houses frequently sustain a constant fire during several months, and sometimes even a year. They become gradually more and more thin, the glass or flux contained probably dissolving them thus slowly.

The quantity of burnt clay in the composition for crucibles varies in proportion to the nature of the crude clay from 1, 2, 2½, or even three parts of the former, to one of the latter. In general, the stronger, more tenacious, and compact the crude clay is, the larger quantity of burnt clay ought to be mixed with it.

The crucibles made in France are composed on the same principles. They are made of clay, mixed with broken butter-pots, which are a stone-ware made in Normandy and Picardy. These crucibles resist admirably well sudden heat and cold, and they would be excellent if the crude clay which enters into their composition was capable of resisting a violent fire; but this clay being mixed with martial and pyritous matters swells in the fire, and begins to melt. Besides, these crucibles owe their good quality of not breaking by sudden application of heat and cold to their little density, which is attended with this inconvenience, that they are penetrable by very fluid matters.

We may from what has been said perceive the difficulty, perhaps the impossibility, of making perfect crucibles. Pott has made so many experiments on this subject, that he seems to have exhausted it. The basis of all his compositions was clay; but this he mixed in different proportions with metallic oxides, burnt bones, calcareous stones, talcs, amianthus, asbestus, pumice-stones, tripoli, and many others, from none of which did he obtain a perfect composition, as may be seen from his Dissertation: hence it may be concluded, that we must have in our laboratories crucibles of different kinds suitable to the several operations.

Crucibles may possibly be made better than any hitherto known, and of more extensive use. The essential point is to obtain a very refractory clay free from pyritous matter and ferruginous earth, from which the sand must be washed. This must be mixed with two or three parts of the same clay baked and pounded grossly; and of this mixture or paste, crucibles must be formed in moulds, and baked in a very strong fire. As retorts and cucurbits are designed for the distillation of liquors generally very corrosive and penetrating, they ought to be made of stone-ware. To this the following observations may be added:

1. Crucibles made of fat clays are more apt to crack, when suddenly exposed to heat, than those made of lean or meagre clays. Meagre clays are those in which a considerable quantity of sand is mixed with the pure argillaceous earth, and fat clays are those which contain but a small proportion of sand.

2. Some crucibles become porous by long exposure to fire, and imbibe part of the contained metals. This inconvenience is prevented by glazing the internal and external surfaces, which may be done by moistening these with oil of tartar, or by strewing upon them, when wetted with water, powdered glass of borax. These glazings are not capable of containing glass of lead.

3. Crucibles made of burnt clay grossly powdered, together with unburnt clay, were much less liable to crack by heat than crucibles made of the same materials, but in which the burnt clay was finely powdered, or than crucibles made entirely of unburnt clay.

4. If the quantity of unburnt clay be too great, the crucibles will be apt to crack in the fire. Crucibles made of ten ounces of unburnt clay, ten ounces of grossly powdered burnt clay, and three drachms of calcined sulphat of iron, are capable of retaining melted metals, but are pervaded by glass of lead. The following composition is as good or better than the preceding:—Seven ounces of unburnt clay, fourteen ounces of grossly powdered burnt clay, and one drachm of calcined sulphat of iron. These crucibles may be rendered more capable of containing glass of lead, by lining their internal surfaces, before they are baked, with burnt clay diluted with water. They may be farther strengthened by making them thicker than is usually done, or by covering their external surfaces with some unburnt clay, which is called arming them.

5. The composition, of which crucibles the most capable of containing glass of lead were made, was eighteen parts of grossly powdered burnt clay, as much unburnt clay, and one part of fusible spar. These crucibles must not, however, be exposed too suddenly to a violent heat.

6. Crucibles capable of containing very well glass of lead, were made of twenty-four parts of unburnt clay, four parts of burnt clay, and one part of chalk. These require to be armed.

7. Plume-alum powdered, and mixed with whites of eggs and water, being ap-

plied to the internal surface of a Hessian crucible, rendered it capable of containing glass of lead during a long time.

8 One part of clay, and two parts of Spanish chalk, made good crucibles. The substance called Spanish chalk is not a calcareous earth, but appears to be a steatites.

9. Two parts of Spanish chalk, and one part of powdered tobacco pipes, made a good composition for lining common crucibles.

10. Eight parts of Spanish chalk, as much burnt clay, and one part of litharge, made solid crucibles.

11. Crucibles made of black lead are fitter than Hessian crucibles for the melting of metals; but they are so porous, that fused salts pass entirely through them. They are more tenacious than Hessian crucibles, are not so apt to burst in pieces, and are more durable.

12. Crucibles placed with their bottoms upwards are less apt to be cracked during the baking than when placed differently.

13 The paste of which crucibles are made ought not to be too moist, else when dried and baked they will not be sufficiently compact: hence they ought not to be so moist as to be capable of being worked on a potter's lathe, but they must be formed in brass or wooden moulds. See Pott's Dissertation on Chemical Vessels.

Scheffer says, that the best crucibles cannot easily contain metals dissolved by sulphur, in the operation of parting by means of sulphur. See Parting. He says, that they may be made much more durable and solid, by steeping them a few days in linseed oil, and strewing powdered borax upon them before they are dried. *Mem. Sued.* xiv, 1752.

POTSTONE.—A mineral of a greenish grey colour, generally found in beds with serpentine, remarkably soft. It may be turned into vessels of various shapes.

POWDER, Gun. See Gunpowder.

POWER, in *Mechanics*. See Mechanics.

PRESERVATION, is the art of preserving animal and vegetable substances from putrefaction or decay. On several occasions, we mentioned the use of different simple and compound bodies which are, or may be, used for this purpose. See the articles Bacon, Beef, Cheese, Pickle, Purification, &c.

PRESS, *Simmon's Patent*. See Mechanics.

PRESS, Screw. See Mechanics.

PRESS, Water. See Hydraulics.

PRESS, Pumice. See Pumice-press.

PRINCES METAL. See Copper.

PRINTERS, or PRINTING INK. See Ink.

PRINTING, is the art of taking impressions from types, &c. This, like other arts has been much improved; the construction of presses, the formation of types, ink, &c. has rendered the art at present more perfect than in the earlier periods of the discovery. For the history and progress of printing, we refer the reader to Thomas's History of Printing, an American publication.

It may not be thought amiss to mention, however, that the art, according to Willich, is divided into three distinct branches; namely, 1. From copper-plates, for pictures, which is denominated *rolling-press printing*. 2. From blocks, on which birds, flowers, and other representations are cut, for printing linen, cotton, or similar articles, and which is known under the name of *calico-printing*. 3. From moveable letters, for multiplying books, and which has received the appellation of *letter-press printing*.

The branch last mentioned, is undoubtedly the most curious and valuable; as to its general dissemination, may be chiefly attributed the progress of learning; the numberless discoveries and improvements in the arts and science, together with a variety of other valuable contrivances in domestic life, that must otherwise have been confined to the knowledge of a few individuals, if not totally lost to mankind. Hence, several cities have contended for the honour of its first introduction; but the claim is confined principally to Haarlem, in Holland (where it was invented by Laurence Coster), and to Mentz, in Germany (where Faust and Guttenberg were the first printers): to each of these it may in some measure be ascribed; the printing with *separate wooden types* being first practised at Haarlem in 1430; as that with metal types (which were first cut, and afterwards cast) was discovered at Mentz, in the year 1444, or 1445.

From Holland, the art of printing was introduced into England, about the middle of the 15th century: it was first carried on at Oxford; whence it has been diffused to every quarter of the island, and is now brought near to the acme of perfection.

In the year 1795, the Society for the Encouragement of Arts, &c. conferred a bounty of 40 guineas on Mr. Ridley, for his invention of a printing press, on a new construction; but, as a description of its mechanism would be intelligible only to printers, the reader is referred to the 13th volume of the Society's "Transactions,"

where it is accurately described, and illustrated with an engraving.

Mr. Fessenden, in his Register of Arts, observes, that "in the art of printing, an important improvement invented by Mr. Hugh Maxwell, has been made and in practical use in three printing offices of Philadelphia. The improvement consists of a roller used for inking the type. The advantages of which are greater regularity in the distribution of the ink, a perfect equality of colour, with a trifling attention, a considerable saving in the expense of printing, and a cleanliness, as respects picks, monks, and friars, not to be attained by the utmost care with the common balls. Another advantage which will be felt by every printer who adopts this plan, the accident of drawing letters so destructive to printing type, so injurious to part of the machinery of the press, and frequently productive of gross errors, is totally avoided.

The machine is light and pleasant work for a boy of ten or twelve years of age, and proves on actual trial a saving on each press to which it is constantly used of about six dollars per week, and the quantity of work performed on one press is more than what can be done in the usual way. One of those machines has been in constant operation for 7 months, and during that period has not required one hour's attention. There is no preparation necessary, but cleaning, which is performed in a few minutes. The trouble of preparing new balls, and knocking up balls, which on the old plan consumes so much time, is in this machine totally saved. It is computed, that in saving of time, one fifth more can be done per day than on the old plan, with all the superiorities enumerated."

However great the improvement may appear, the roller can never render the printing or impression uniform; with this and other objections, the supposed improvement is abandoned, and, we believe, the plan is only used in one or two offices.

PRINTING, of Calico. Calico printing is the art of communicating different colours to particular spots or figures, on the surface of cotton or linen cloth, while the rest of the stuff retains its original whiteness.

This ingenious art seems to have originated in India, where we know it has been practised for more than 2000 years. It has but lately been cultivated in Europe; but the enlightened industry of our manufacturers, has already improved prodigiously, upon the tedious processes of their Indian masters. No art has arisen to perfection with greater celerity: a hundred years ago, it was scarcely known in Europe; at present, the elegance of the patterns, the beauty and permanency of the colours, and the expedition with which the different operations are carried on, are really admirable.

Calico printing consists, in impregnating those parts of the cloth, which are to receive a colour, with a mordant, and then dyeing it as usual, with some dye stuff or other. The dye stuff attaches itself firmly, only to that part of the cloth which has received the mordant. The whole surface of the cotton, is indeed more or less tinged, but by washing it, and bleaching it for some days on the grass, with the wrong side uppermost, all the unmordanted parts resume their original colour, while those which have received the mordant, retain it. Let us suppose that a piece of white cotton cloth, is to receive red stripes: all the parts where the stripes are to appear, are pencilled over with a solution of acetite of alumine; after this, the cloth is dyed, in the usual manner with madder. When taken out of the dyeing vessel, it is all of a red colour, but by washing and bleaching, the madder leaves every part of the cloth white, except the stripes impregnated with the acetite of alumine, which remain red. In the same manner may yellow stripes, or any other wished-for figure, be given to cloth, by substituting quercitron bark, weld, &c. for madder.

When different colours are to be given, to different parts of the cloth at the same time, it is done by impregnating it with various mordants. Thus, if stripes be drawn upon a cotton cloth, with acetite of alumine, and other stripes with acetite of iron, and the cloth be afterwards dyed in the usual way with madder, and then washed and bleached, it will be striped red and brown. The same mordants with quercitron bark, give yellow and olive, or drab.

The mordants employed in calico printing, are acetite of alumine, and acetite of iron, prepared in the manner described, in the article on dyeing. These mordants are applied to the cloth, either with a pencil, or by means of blocks, on which the pattern, according to which the cotton is to be printed, is cut. As they are applied only to particular parts of the cloth, care must be taken that none of them spread, to the part of the cloth which is to be left white, and that they do not interfere with one another, when more than one are applied. If these precautions be not attended to, all the elegance and beauty of the print must be destroyed. It is necessary, therefore, that the mordants should

be of such a degree of consistence, that they will not spread beyond those parts of the cloth, on which they are applied. This is done by thickening them with flour or starch, when they are to be applied by the block; and with gum-arabic, when they are to be put on by a pencil. The thickening should never be greater, than is sufficient to prevent the spreading of the mordants; when carried too far, the cotton is apt not to be sufficiently saturated, with the mordants; of course the dye, takes but imperfectly.

In order that the parts of the cloth impregnated with mordants, may be distinguished by their colour, it is usual to tinge the mordants, with some colouring matter or other. The printers commonly use the decoction of Brazil-wood for this purpose; but Dr. Bancroft has objected to this method, because he thinks that the Brazil-wood, colouring matter, impedes the subsequent process of dyeing. It is certain, that the colouring matter of the Brazil-wood, is displaced during that operation, by the superior affinity of the dye stuff, for the mordants. Were it not for this superior affinity, the colour would not take at all. Dr. Bancroft advises, to colour the mordant with some of the dye stuff, afterwards to be applied; and he cautions the using of more for that purpose, than is sufficient to make the mordant distinguishable, when applied to the cloth. The reason of this precaution is obvious. If too much dye be mixed with the mordant, a great proportion of the mordant, will be combined with colouring matter, which must weaken its affinity for the cloth, and of course prevent it from combining with it, in sufficient quantity, to ensure a permanent dye.

Sometimes these two mordants, are mixed together in different proportions; and sometimes one or both is mixed with an infusion of sumach, or of nut-galls. By these contrivances, a great variety of colours are produced, by the same dye stuff.

After the mordants have been applied, the cloth must be completely dried. It is proper for this purpose, to employ artificial heat, which will contribute something towards the separation of the acetous acid from its base, and towards its evaporation, by which the mordant will combine in a greater proportion, and more intimately with the cloth.

When the cloth is sufficiently dried, it is to be washed with warm water and cow-dung, till all the flour, or gum, employed to thicken the mordants, and all those parts of the mordants, which are uncombined with the cloth, be removed. The cow-dung serves to entangle these loose parts of the mordants, and to prevent them from combining, with those parts of the cloth which are to remain white. After this, the cloth is thoroughly rinsed in clean water.

Almost the only dye stuffs employed by calico printers, are indigo, madder, and quercitron bark, or weld. This last substance, however, is but little used by the printers of this country, except for delicate greenish yellows. The quercitron bark has almost superseded it, because it gives colour equally good, and is much cheaper and more convenient, not requiring so great a heat to fix it. Indigo not requiring any mordant, is commonly applied at once, either with a block or a pencil. It is prepared by boiling together indigo, potash made caustic by quick-lime, and orpiment; the solution is afterwards thickened with gum. It must be carefully secluded from the air, otherwise the indigo would soon be regenerated, which would render the solution useless. Dr. Bancroft has proposed to substitute coarse brown sugar for orpiments: it is equally efficacious in decomposing the indigo, and rendering it soluble; while it likewise serves all the purposes of gum.

When the cloth, after being impregnated with the mordant, is sufficiently cleansed, it is dyed in the usual manner The whole of it is more or less tinged with the dye stuff. It is well washed, and then spread out for some days on the grass, and bleached with the wrong side uppermost. This carries the colour off completely, from all the parts of the cotton which have not imbibed the mordant, and l aves them of their original whiteness, while the mordanted spots retain the dye as strongly as ever.

Let us now give an example or two, of the manner in which the printers give particular colours to calicoes. Some calicoes are only printed of one colour, others have two, others three or more, even to the number of eight, ten, or twelve. The smaller the number of colours, the fewer in general, are the processes.

1. One of the most common colours on cotton prints, is a kind of nankeen yellow, of various shades, down to a deep yellowish brown, or drab It is usually in stripes or spots. To produce it, the printers besmear a block, cut out into the figure of the print, with acetite of iron, thickened with gum or flour: apply it to the cotton, which, after being dried and cleaned in the usual manner, is plunged into a potash ley. The quantity of acetite of iron

is always proportioned to the depth of the shade.

2. For yellow, the block is besmeared with acetite of alumine. The cloth, after receiving the mordant, is dyed with quercitron bark, and then bleached.

3. Red is communicated by the same process; only madder is substituted for the bark.

4. The fine light blues which appear so often on printed cottons, are produced by applying to the cloth, a block besmeared with a composition, consisting partly of wax, which covers all those parts of the cloth which are to remain white. The cloth is then dyed in a cold indigo vat; and after it is dry, the wax composition, is removed by hot water.

5. Lilac flea brown, and blackish brown, are given by means of acetite of iron; the quantity of which is always proportioned to the depth of the shade. For very deep colours, a little sumach is added. The cotton is afterward dyed in the usual manner with madder, and then bleached.

6. Dove colour and drab, by acetite of iron, and quercitron bark.

When different colours are to appear in the same print, a greater number of operations are necessary. Two or more blocks are employed, upon each of which, that part only of the print is cut, which is to be of some particular colour. These are besmeared with different mordants, and applied to the cloth, which is afterwards dyed as usual. Let us suppose for instance, that these blocks are applied to cotton, one with acetite of alumine, another with acetite of iron, a third with a mixture of those two mordants, and that the cotton is then dyed with quercitron bark, and bleached. The parts impregnated with the mordants, would have the following colours.

Acetite of alumine,	Yellow.
——— iron,	Olive, drab, dove.
The mixture,	Olive green, olive.

If part of the yellow be covered over with the indigo liquor, applied with a pencil, it will be converted into green. By the same liquid, blue may be given to such parts of the print as require it.

If the cotton be dyed with madder, instead of quercitron bark, the print will exhibit the following colours.

Acetite of alumine,	Red.
——— iron,	Brown, black.
The mixture,	Purple.

When a greater number of colours are to appear; for instance, when those communicated by bark, and those by madder, are wanted at the same time, mordants for part of the pattern are to be applied; the cotton is then to be dyed in the madder bath, and bleached; then the rest of the mordants, to fill up the pattern, are added, and the cloth is again dyed with quercitron bark, and bleached. The second dyeing does not much affect the madder colours: because the mordants, which render them permanent, are already saturated. The yellow tinge is easily removed, by the subsequent bleaching. Sometimes a new mordant is also applied, to some of the madder colours, in consequence of which, they receive a new permanent colour from the bark. After the last bleaching, new colours may be added by means of the indigo liquor. The following table will give an idea of the colours, which may be given to cotton by these complicated processes.

I. *Madder Dye.*	*Colours.*
Acetite of alumine,	Red.
——— iron,	Brown, black.
——— diluted,	Lilac.
Both, mixed,	Purple.
II. *Bark Dye.*	
Acetite of alumine,	Yellow.
——— iron,	Dove, drab.
Lilac and acetite of alumine,	Olive.
Red and acetite of alumine,	Orange.
III. *Indigo Dye.*	
Indigo,	Blue.
Indigo and yellow,	Green.

Thus no less than 12 colours may be made to appear together in the same print, by these different processes.

These instances will serve, to give the reader an idea of the nature of calico printing, and at the same time afford an excellent illustration, of the importance of mordants in dyeing.

If it were possible to procure colours sufficiently permanent, by applying them at once to the cloth, by the block or the pencil, as is the case with the mordants, the art of calico printing, would be brought to the greatest possible simplicity; but at present, this can only be done in one case, that of indigo; every other colour requires dyeing. Compositions, indeed, may be made, by previously combining the dye stuff, and the mordants. Thus yellow may be applied at once, by employing a mixture of the infusion of quercitron bark, and acetite of alumine; red, by mixing the same mordant, with the decoction of alumine, and so on. The co-

lours applied in this way, are unfortunately, far inferior in permanency, to those produced when the mordant is previously combined with the cloth, and the dye stuff afterwards applied separately. In this way are applied, almost all the fugitive colours of calicoes, which washing, or even exposure to the air destroys.

As the application of colours in this way, cannot always be avoided by calico printers, every method of rendering them more permanent, is an object of importance.

On the subject of calico printing, the reader may find some useful observations in the American edition of Willich's Domestic Encyclopedia, drawn up principally by the now professor Cooper. The remarks already given in the preceding ac count, may prove useful by the following additional observations extracted from Aikin's Chemical Dictionary.

To apply a coloured pattern on a white or coloured ground, only two general methods appear practicable, the one, to weave the pattern into the cloth with threads dyed of the requisite colours, the other to devise some method of topical dyeing, which shall, like a picture, confine the desired colours to those parts only that are figured by the intended patterns. The former is the delicate business of the embroiderer or the tapestry weaver; the latter is the ingenious art of the calico-printer.

It is particularly, though not entirely, with the adjective colours, or those that require a mordant, that calico-printing is concerned, as this very circumstance affords a ready method of giving a permanent colour only to the pattern part; for if this latter only is impregnated with the mordant, and the whole cloth is then uniformly dyed, the natural effect of exposure to sun and air, will be to discharge all the colour from every part of the cloth except where it had previously received the mordant, and thus a coloured pattern will be produced on a white ground.

This partial application of mordants, therefore, followed by general dyeing, constitutes the greater part of calico-printing, besides which, however, a further variety of application often occurs, as sometimes colours themselves are painted or pencilled in to assist the general effect, which therefore require no subsequent operation; and occasionally other contrivances are used to fix, or alter, or discharge colours, according as the proposed pattern may require it.

Two mordants are more particularly used by calico-printers, though equally serviceable in general dyeing, the one is acetite of alumine with a portion of alum, the other is a solution of iron in some vegetable acid.

The acetite of alumine is always made by double decomposition of alum and sugar of lead, but the proportions of each vary much, according to circumstances, and probably to the fancy of the colour-mixer. In general, three pounds of alum (or in that proportion) are thrown into a barrel, and when dissolved, a pound to a pound and a half of sugar of lead are added, and the whole often stirred for two days. On settling, a clear liquor is found at top which consists of acetite of alumine, but still containing much undecomposed alum, and a dense white sediment remains at bottom, which is sulphat of lead. The clear liquor is the part used for the mordant, but previously two ounces of pearlash and as much chalk are added, more entirely to neutralize any excess of acid, and partly to decompose the solution; for though the mordant must be in a saline state entirely to fix itself to the fibres of the cotton, it should seem that the true intermede between the cotton and the dye is the alumine, and not the acids that hold it in solution, and hence the weaker the adhesion of these is to the alumine, and the stronger will be the triple union between the colour, the earth, and the cotton fibre.

The other mordant constantly in use with the printers is a solution of iron in vinegar, soured beer, pyroligneous acid, or other vegetable acids, and which therefore is chiefly an acetite of iron mixed with a portion of tartrite, perhaps gallat, and other salts of this metal.

To make these mordants fit for printing, and give them such a consistence as will enable them to dry in a figured pattern without running into the adjoining parts, they are thickened with paste to the consistence of jelly; and when to be used, this jelly is squeezed through a very fine sieve by a particular and simple contrivance, on the surface of which it lies as a thin coating convenient to be transferred to the printing blocks.

The mordant, when naturally colourless, is a little tinged with Brazil wood (which being a very fugitive dye does not impair the general effect) that the workman may see the impression on the cloth and fix the pattern with accuracy.

The instrument by which the impression is given (or what answers to the types in the printing of books) is a piece of hard wood, generally holly, about a foot long, on which the pattern is carved, nearly as in wood engraving, and is strengthened at the back with a thicker piece of

oak glued on. The parts of the pattern that are to receive a large body of colour, and consequently require a corresponding quantity of mordant, are given by pieces of old hat inlaid into the block, which are found to take up the mordant in a more uniform way than any other material Of late years also some of the finer patterns are given by sheet-copper fixed on a block like fillagree work, which gives a finer and sharper line to the figured pattern. Fine work is sometimes given still more expeditiously by engraved copper-plate and the rolling-press as in common picture engraving.

The general process of the simple kind of calico-printing, therefore, is the following: the cotton cloth, previously bleached with alkali and much washing, and calendered to smooth the surface, is stretched on a long table covered with woollen cloth, when the printer first lays the block on the sieve that contains the mordant, then applies it steadily on the cloth, and strikes it a smart blow on the back with a wooden mallet to give a strong impression. This he repeats successively, each time carefully laying the block in the proper direction so as not to overlap the last impression, till the whole is finished.

In this way the patterns are impressed with one or more kinds of mordant as may be required, after which the cloth is strongly dried in a stoved room, which both fixes the mordant more firmly to the cotton, and volatilizes much of the acetous acid in fumes very sensible to the smell. When dry, the cloth is taken to a cistern containing very warm water, in which cow-dung is diffused, and there it is worked about to dissolve out the paste and other superfluous part of the mordant, sufficient being yet left firmly united to the fibres of the cloth to fix the dye in the subsequent process. The cloth is then rinced and thoroughly cleaned, after which it is dyed in the usual way. The cloth comes out of the dyeing cistern entirely coloured (yellow, for example, when the dye has been weld); it is then again washed with water, boiled with bran and water, alternating with exposure to air on the bleach-field, and other bleaching processes, till at last all the colour of the ground has disappeared, and that only remains which has been fixed to the pattern by the mordant.

The above is the simplest process, that is, in which all the mordants are laid on first, and the colour is given by a single dyeing afterwards, and by merely varying the mordants a considerable variety of shades may be given. Thus, for example, if one pattern be printed with the aluminous mordant alone, a second with the mixture of the former mordant with iron liquor, a third with iron liquor alone, and a fourth with iron liquor and galls, and the piece be afterwards dyed with quercitron or weld, and the ground bleached in the usual manner, the first pattern will be of a pure yellow, the second will be olive, the third of a dark drab colour, and the fourth nearly black, whilst the ground will be white.

Cloth that has been thus printed with one course of colours, is often subjected to a similar process for a different course with another dye, where the intended pattern requires a great variety of colours.

Thus when all the reds, purples, browns, &c. have been given by a course of madder, the cloth with part of the patterns thus finished, may be made to undergo a course of mordants to be afterwards dyed with quercitron for other parts of the pattern. In this case, however, much judgment is required to employ only those successions which will not materially injure each other. It might be at first supposed, that when a pattern dyed red (for example) with madder and an alum mordant came to be immersed in a decoction of weld without any fresh mordant, that the former would not be at all affected by the latter, or at least that the effect would soon be destroyed by bleaching; but this is not found to be altogether the case, for adjective colours appear to have also their *relative* affinities for mordants, therefore as a fast madder red is a compound of alum and alumine, if madder has a less affinity for alumine than weld, the colour will be in part decomposed, and some of the weld will displace a portion of the madder. Hence the colour will be changed into a triple compound of madder, weld, and alumine, and the dye proportionally altered. It appears, therefore, that in printing successive courses of colours, attention should be paid to print first those whose affinities for the mordants are the strongest, and finish with the weakest, unless indeed (which is sometimes the case) the change produced by the intermixture of colours be a part of the desired effect. But much remains to be done towards a rational explanation of the complicated affinities and mutual action of mordants and colouring matter, and of the apparently slight variations by which, however, the skilful printer is enabled to produce effects which at present a person could hardly hope to imitate without a large share of practical experience.

Another part of calico-printing is the impression of *colours*, for hitherto that of

mordants only has been mentioned. In this case also, as in general dyeing, the substantive colours do not, and the adjective colours do, require to be previously mixed with their proper mordant. Pattern colours are applied either by the block (as the mordants are) or by pencilling or painting. In the latter case the colour is thickened, not with paste, but with gum arabic or senegal, and it is applied with a camel's hair brush. The pencilled colours require no further dyeing operation, and are only finished by washing and drying, so that it is usually the last parts of the pattern, that are given in this way.

Indigo is the only substantive colour used for pencilling, but here a very great difficulty presents itself; for indigo (as already mentioned in describing the blue dye) is only a fast colour when in its disoxygenated state, in which it is yellow or green; but when much exposed to air, as can hardly be avoided in the slow and minute process of pencilling, part of it returns to the blue or oxygenated state before it has properly fixed itself on the stuff, and this portion is carried away in the subsequent washing. It is therefore very seldom that the pattern of a whole piece can be indigo-pencilled with the same uniformity with which some of the other colours are given The solution used for this purpose is usually made of a large proportion of indigo dissolved in potash, rendered caustic by lime, to which is added orpiment for the deoxygenation of the indigo. This latter effect is also often produced wholly or in part, by the cheaper kind of raisins. The solution is then thickened by gum, and should be kept in a close stopped vessel, and no more exposed to air than is necessary for immediate use.

This indigo-blue is also often pencilled upon figures previously dyed yellow in order to produce a permanent green, but with some little injury to the yellow ground by the caustic alkali contained in the indigo solution.

Adjective colours are sometimes mixed with their proper mordant, and used in this state for pencilling without any other preparation. Such a mixture has therefore the effect of a substantive colour. Thus if a very strong decoction of weld or quercitron is added to a mixture of alum and sugar of lead, and the whole duly thickened, a yellow of a certain degree of durability is formed at once, and may be printed or pencilled on a white ground to produce a yellow, on an indigo ground to give a green, on a red madder ground to give an orange, and the like.

It is found, however, that adjective colours, when first fixed with their mordants, and then applied to cotton, have very little durability compared to that of the method of first applying the mordant thoroughly, and then the colour. This difference holds good in the general as well as topical dyeing of cotton and linen with all adjective colours, as has already been fully described, though with regard to wool it appears to be often a matter of indifference as to the fixity of the colour, whether the mordant and the dye are applied separately or united. Thus woollen cloth may be dyed with cochineal and tin, apparently equally well in one as in two operations. But as this does not hold with cotton, it still remains a great object in calico-printing to discover some method of pencilling adjective colours so as to be sufficiently durable. It is also an additional difficulty to this object, that the pencilled colours always require a very full body of colour, being generally applied rather as finishing touches to the pattern than constituting any very large portion of it.

In many cases parts of the pattern itself are required to be white. Sometimes this may be done simply in the way that the ground is left white, that is, by leaving these parts untouched by any mordant, so that when the whole is dyed with an adjective colour, subsequent washing and bleaching will destroy the dye on these untouched parts. This plan, however, is obviously inadmissible when the general dye is given by a substantive colour as indigo. In such cases some kind of covering must be applied to the white pattern parts to protect them from the dye, and hinder it from penetrating. In the East Indies wax is often used topically on the white parts for this purpose. In this country a mixture of pipe clay and paste is sometimes used. In these cases the cold indigo vat is of particular service, as the covering for the white is much less liable to be dissolved out, than in the usual way of dyeing in a heated bath.

But in the common method of producing white with adjective colours, the smaller parts of the pattern are seldom so well defined and thoroughly bleached as to render the work perfect. With every care some part of the adjoining printed mordant will often spread a little beyond its proper limits, and occasion a permanent soil on the white, besides that the removing some stains by bleaching, particularly those from the weld bath, is tedious and difficult To remedy this, therefore, and to give a perfectly clear and well defined pattern white to the parts without mordant, which so much

improves the general effect, the bleaching power of *acids* has lately been much resorted to. Most of the acids possess this power, but the stronger mineral acids are so liable to affect the texture of the cotton when sufficiently strong, that they cannot be employed. Recourse, therefore, has been had to the stronger vegetable acids, and of these the *Citric*, either in its crystallised state, or merely as lemon juice concentrated by boiling, holds the first place, and this article has of late years been consumed by the printers of England to a vast amount. It is usually applied by the block like the common mordants. The particulars of the preparation of the *Citric* acid are described under that article.

PRINTS, *Cleansing of*.—Various methods have been recommended for cleansing prints. Some observations to this purpose have been given in the article PICTURE. We will only add, in this place, that the best means consists in immersing them for a short time in weak oxygenized muriatic acid. The preparation of this acid may be seen in the article; also in the article BLEACHING, and in the Appendix to vol. i.

PROGNOSTICS of the Weather. See METEOROLOGY.

PROP. See MECHANICAL POWERS.

PRUSSIC ACID.—This acid is important in the arts only as respects its combination with iron, in the formation of Prussian blue. It is found chiefly during the decomposition of animal substances at high temperatures. The following is the process generally used, which is effected by the decomposition of prussiat of iron. For the preparation of prussiat of iron, see *Prussian blue*, art. COLOUR-MAKING.

Mix two ounces of red precipitate of mercury with four ounces finely powdered Prussian blue, and boil the mixture with twelve ounces of water in a glass vessel, shaken frequently. Filter the solution, which is a prussiate of mercury, while hot; and, when cool, add to it two ounces of iron filings, and six or seven drachms of sulphuric acid; shake these together, decant the clear liquor into a retort, and distil off one-fourth of the liquor. The distilled liquor is the prussic acid, which has a peculiar smell, a sweet taste, and does not, like other ácids, redden vegetable blue colours, but combining with alkalies and earths. In addition to its combination with iron as a pigment, we may mention also that its combination with copper furnishes a brown pigment, which has lately been introduced into use.

PRUSSIAN BLUE.—See COLOUR-MAKING.

PRUSSIAN BROWN.—This preparation we have so named from the combination of prussic acid with a metallic base, which is copper. It is made by adding a solution of prussian alkali (made by calcining blood, or bones, with potash,) to another solution of sulphate of copper or blue vitriol. The effect is a mutual decomposition, and the precipitation of oxyd of copper in union with prussic acid. We have already spoken of its use as a pigment; by some it is considered superior to the finer ochres, or browns.

PRUSSIAN ALKALI, or *Prussiat of Potash*.—This preparation is used in the manufacture of prussian blue; but, for the nicer purposes of chemistry, the mode of preparing, differs from that already noticed. See TESTS.

PULLEY. See MECHANICS.

PUMICE PRESS.—A new pumice-press was invented by Mr. Timothy Matlack, formerly of Lancaster, but now of this city. The common press, called also the cyder-press, is well known; but we shall add a few observations on the improvement of Mr. Matlack. The press was intended originally for making wines from currants, black berries, grapes, and other small fruits, which he afterwards extended for the making of perry, and cyder. Mr. M. adds, that it is capable of almost incredible force, within a *small space*, by very simple means, and at a very small expense; and also, that it can be used with the greatest facility, and when done with for the season, can be laid securely by, without occupying much house room. The press consists of a double lever, which is to press 40 for 1. The crib, in which the fruit is put, may contain 40 bushels, which may be wrought at least three times, while one of 80 bushels can be wrought once in the common mode. The crib is 21 inches by 20, and 20 inches high. The first lever, which immediately acts upon the pumice placed in the crib, is six feet eight inches, equal to five times the length below the fulcrum. The second lever is six feet eight inches, and is connected to the first by a chain We shall state, in the words of the inventor, some particulars relative to the power.

"The pressure of the weight (100 lbs.) on the pumice, is as five times five to one; that is, its pressure downwards is equal to 2,500 pounds. But, the uprights being fastened to the side planks, the toe of each lever bears the crib upwards with the same power as the heel (or fulcrum) presses downwards; so that the actual pressure on the pumice is equal to 5,000 pounds. The press is provided with two of these compound levers, acting side by

side, and consequently press equal to 5,000 pounds; although the uprights are five inches apart, and by lengthening the pin which supports the levers only five inches, two more of those levers may be added on the outsides of the uprights, which will press equal to another 10,000 pound, and so infinitely." For further remarks, and a view of the machine, see the Transactions of the Agricultural Society of Philadelphia, vol. i, page 109.

PUMICE STONE.—The pumice stone, though universally admitted to be the product of volcanic fire, is one of those bodies which have divided the opinion of naturalists. The Abbé Lazaro Spallanzani, who most minutely examined this article, says, that the pumice fields where the common pumice is found, consist of an aggregation of numerous beds or strata of pumices, each bed not forming a distinct whole, but being a collection of balls of pumice, without adhesion; from which he deduces that they were thrown out by the volcano, in a state of fusion; and took a globose form in the air. They are of different sizes, from that of a nut to a foot and more in diameter. Though the ground colour of them all is white, in some it inclines to yellow, and in others to a gray. They swim in water, and do not give fire with steel. Their fracture is dry, and rough to the touch, their angles and thinner parts slightly transparent. Some are so compact, that the smallest pore is not visible, nor do they exhibit the least trace of a filamentous texture; others on the contrary are full of pores and vacuities, and their texture is formed by filaments and streaks, in general parallel to each other, of a shining silvery whiteness.

This is the common pumice stone known amongst us, and the only kind constituting an article of commerce from the Mediterranean to this country.

There are several other varieties, particularly one of a dark dirty, and another, of a pale red colour; both to be found, not loose, but in solid beds, and cut by the labourers in form of parallelopipeds. Both the latter sorts are used in Italy for building arched vaults, cornices, &c. but do not constitute an article of foreign commerce.

According to Klaproth, pumice is composed of 77.5 of silex, 17.5 alumine, and 1.75 oxyd of iron.

The greatest quantity of pumice to be met with any where is at the Campo Bianco, in the island of Lipari, a mountain about a quarter of a mile in breadth. The rock also, upon which the castle of Lipari is built, is an immense heap of lava, glass, and pumice stones; which latter, in fact, are nothing else but an imperfect glass, or a volcanous ejection, which, if exposed to a greater degree of heat, would have been changed into a vitreous mass. Small quantities of pumice are found also in the Arso, in the island of Ischia. But a place in Europe, which in the abundance of its pumices can equal, or perhaps surpass Lipari, is the island of Santorine in the Archipelago, almost covered with pumice stone. Many eruptions of pumices are in the Phlegrean field; one of which overwhelmed the unfortunate town of Pompeii.

Pumice stone is used in several mechanical arts; as, for rubbing and smoothing the surface of metals, wood, pasteboard, and stone; for which it is well qualified by reason of its harsh and brittle texture.

PUMP See Hydraulics, and Engine *for raising Water.*

PUMP, *Forcing* See Hydraulics.

PURPLE, in *Dyeing*. See Dyeing.

PUTTY, for *Glaziers*, is a mixture of whiting and linseed oil, combined together in proper proportions.

PUTTY, *Polishing*.—This preparation is made by calcining an alloy of equal parts of tin and lead, but it is said to be made, when genuine, by the calcination of tin only. A white powder is thus produced that is the base of most of the opake enamels, and is also used in the polishing of metals, stones, and glass.

PUZZOLANA.—This is a volcanic production of a gray, brown, yellowish, or blackish colour, loose, granular, or dusty and rough, porous and spongy, resembling a clay hardened in fire, and then reduced to a gross powder. It contains, mixed with it, various heterogeneous substances. Its specific gravity is from 2.5 to 2.8 and it is in some degree magnetic: it scarcely effervesces with acids, though partially soluble in them: it melts easily per se: but its most distinguishing property is, that it hardens very suddenly when mixed with one-third of its weight of lime and water, and forms a cement which is more durable in water than any other. According to Bergman's analysis, one hundred parts of it contain from 55 to 60 of siliceous earth, 19 or 20 of argillaceous, 5 or 6 of calcareous, and from 15 to 20 of iron. It is evidently a martial argillaceous marl that has suffered a moderate heat. Its hardening power arises from the dry state of the half-baked argillaceous particles, which makes them imbibe water very rapidly, and thus accelerates the desiccation of the calcareous part; and also from the quantity and state of the irom con-

tained in it. It is found not only in Italy, but also in France, in the provinces of Auvergne and Limoges, and elsewhere.

Not only the volcanic puzzolana, but the poor siliceous iron-stones are capable of forming a very hard cement, that will set in water. They should be calcined so as to be of a deep brown for this use; if more slightly torrefied, they make a very hard cement in the open air.

Many experiments have proved to M. Dodun that the puzzolana, which soonest forms a body in the water, is not fit to be employed in the open air, where it cracks and chaps in all directions And that which is proper for the air, and which acquires and preserves its tenacity in it, sets but imperfectly in water. This difficulty, of which the Institute perceived the cause, has obliged him to keep two sorts of the factitious puzzolana; on the reciprocal use of which a memoir of instruction accompanies the sale. The two sorts may be distinguished by their colour.

The factitious puzzolana proper for works under water, is of a reddish brown. That which is fit for work exposed to the air, is a dark violet. The latter is used for terraces, the embankments of basons, for the composition of inclosures, or for light roofs. Bridges of a single arch may be formed with it; and it adheres so strongly to glazed tiles, that it is sometimes necessary to break the tiles to detach it.

The puzzolana proper for constructions beneath the water, forms the most solid body in it. Three months after immersion it is an actual stone, capable of receiving a polish. The lime in it is always regenerated into carbonate of lime in ten weeks.

When it may be thought by any one that he has been deceived as to the certainty of these effects, it will always be found, that he either has not observed the quantities directed of the puzzolana and the lime, or that he has used the reverse of that kind of the cement proper for the work.

M. Dodun commonly used lime in the state of impalpable powder, slacked in Lafaye's manner, for works exposed to the air; and employed lime in the state of *putty*, for works which were to be covered with water. Sometimes he used lime in powder for the same work. This difference depends on the degree of goodness of the lime, on its greater or lesser richness, or its proportional poverty. Custom gives the advantage of knowing the different kinds on mere inspection.

The use of lime in powder appeared to him to merit a preference in the preparation of mortars or cements. He prepared his factitious puzzolana in a certain quantity as soon as he knew the proper proportion of the lime; and he had thus the advantage of being able to work it in troughs, in the same manner as sulphate of lime. The whole was well mixed together and put into sacks; by which means the masons had nothing to do with the mixture of the articles, (which is too often left to unprincipled workmen,) and being thus master of the respective proportions of the puzzolana and the lime, he could always be assured of the solidity of his cements.

M. Dodun's discovery may be of some use to this country, as there are in many parts of it large masses of iron stone, and some is found in the vicinity of most coal mines.

It has been long known that iron ochres have the same property of forming puzzolana with lime, when properly roasted, and this circumstance is mentioned at large in Chaptal's Chemistry. A patent has also been obtained in this country for the application of iron pyrites to the same purpose, the right to which was purchased long ago by Mr Samuel Wyatt. But the novelty of M Dodun's discovery is, that poor iron stone is equally fit for this use, as the other substances mentioned, which is of the more importance as it is very plentiful, and may often be procured in situations where the others cannot.

It may not be amiss to mention here, that basalt, treated in the same manner, has the same property as the puzzolana: the whinstone, of which the ovoidal paving stones consist mostly, is of this kind; and it is found in great abundance in these countries, in different forms.

A substitute for puzzolana may be procured in three ways. 1st, By employing the remains of extinguished volcanoes which almost all countries produce. 2dly, By substituting some other volcanic products for puzzolana. 3dly, By giving to certain mineral substances, by calcination, all the properties of these volcanic productions.

We may find a substitute for puzzolana in other volcanic products, such as basalt, pumice stones carefully pounded, &c.

In 1787 M. Guyton de Morveau sent to M. de Cessart at Cherbourg, some calcined basalts from the extinguished volcano of Drevin, in the department of the Var and Loire. The latter proved by conclusive experiments, that they might be employed with great advantage in building under water.

The Dutch terrass is a kind of pumice stone brought from Bonn and Andernach.

At Dordrecht, at the mouths of the Rhine and Meuse, the operation of pounding is effected.

But these resources are local; and as the manufacture of puzzolana may become general, we proceed to describe the best means of attaining it.

It would be difficult to assign the period at which pounded bricks and the earthy residue from the distillation of aquafortis were substituted for volcanic puzzolana. Their use, however, has become general, particularly where there are no sea-ports in the vicinity at which real puzzolana can be furnished: even in the south of France they prefer the earthy residue of the distillation of aquafortis to the best puzzolanas for coating the inside of the wine tubs, which are almost all of mason work, and for the cements used by individuals in hydraulic works. The earth employed in the south of France for the decomposition of saltpetre, by extracting the aquafortis from it, is an ochrey earth very much charged with iron, and more or less reddened by the oxide of this metal. When it is wanted for cement, it is only necessary to beat it up with lime, and a proper quantity of water. M. Lepere relates some experiments made at Paris by the engineers of roads and bridges, from which it appears that an immersion of eight days was sufficient for aquafortis cements to acquire a hardness fit to resist a billet of wood when forced against it with the whole strength of a man; whereas the Italian puzzolana required six weeks before it attained the same degree of hardness.

In general, the quality of the earth is better, in proportion as it is charged with iron.

This last observation is equally applicable to pounded bricks: in general, they do not make a good cement, unless they are well burnt, and made of very ferruginous earth.

The means suggested for making this artificial puzzolana are simple, and may be put in practice almost every where. Balls should be made of the ochrey earth, and burned in a lime or potter's kiln. In order to form these balls, the earth must be moistened with a sufficient quantity of water; and when the balls are made, they should be burned until they pass from a red to a black colour, and the angles of the scales formed when they are broken exhibit sharp and shining edges.

M. Lepere relates that M Vitalis, professor of chemistry, and secretary to the Rouen Academy, and M. Lamassen, chief engineer of the department of the Lower Seine, have made most excellent puzzolana by the calcination of some ochrey earths in the environs of Rouen: this was effected by burning the earth in a common furnace with alternate strata of common charcoal. This puzzolana was subjected to some trials on a large scale, and it was composed in the following manner:

One part and a half of yellow calcined ochrey earth.

One part and three-fourths of well wsshed siliceous sand.

One part and an eighth of sour lime.

Two parts of chip from calcareous stone and silex.

From these and several other experiments (the proportions of which were varied) it results, that the artificial puzzolana constantly exhibited the same effects as the best puzzolana of Italy. M. Lepere was an eye-witness of all these comparative experiments.

There can be no doubt, therefore, that wherever there are ochrey earths, artificial puzzolana may be made with great facility.

What is called Dutch terrass is, in many respects similar to the artificial puzzolana in question.

The ashes, or rather scoriæ, left when coals are burnt, may also be applied to the same purpose. M. Guyton caused a trial to be made at Cherbourg, and it succeeded well.

M. Gratian Lepere, having been intrusted in 1804 with constructing the foundation of the new arsenal at Cherbourg, began to turn his attention to the best method of supplying the puzzolana of Italy. He knew that the Swedes had already used a very hard black slate with this view, after being twice strongly calcined in a lime kiln.

M. Lepere thought he perceived a great analogy between the Swedish stone and the rocks of Cherbourg, particularly those of port Bonaparte, which, when dug into, exhibited a black schistus, hard, ferruginous, and falling off in scales of various thickness: subsequent experiments, however, proved that the slaty schistus of Roule, in the environs of Cherbourg, is preferable, and that good mortar may be made with the ferruginous schist of Haineville, which is inferior, however, to the two former.

After having multiplied and varied his experiments in such a manner as to present positive results, M. Lepere, in conjunction with the committee of engineers appointed to examine his experiments, draws the following conclusions:

1st. That certain kinds of schist, when

strongly calcined and pulverized, form an excellent mortar when mixed with sour lime

2dly. That in order to give precisely the same properties to schist which are possessed by puzzolana and terrass, the former must be calcined in a reverberating, instead of a lime, furnace. See CEMENT.

The following cement for water cisterns, aqueducts, &c. may, with propriety, be here noticed. Mix four parts of gray clay, six of the black oxide of manganese, and ninety of good lime-stone reduced to fine powder; then calcine the whole to expel the carbonic acid. When this mixture has been well calcined and cooled, it is to be worked into the consistence of a soft paste, with sixty parts of washed sand. If a lump of this cement be thrown into water, it will harden immediately. Such mortar, however, may be procured at a still less expense, by mixing with common quicklime a certain quantity of what are called the white iron *ores*, especially such as are poor in iron. These ores are chiefly composed of manganese and carbonate of lime or chalk. Common lime and sand only, whatever may be the proportion of the mixture, will constantly become soft under water.

PYRITES. Certain metallic combinations, which contain a very large proportion of sulphur, are known by this name. They are not indeed entitled to any particular class not distinct from ores; yet their abundance and other properties are sufficient to justify their insertion in a separate article.

Although sometimes pyrites contains more metal than some ores, yet generally it contains less metal, and a larger quantity of mineralizing substances, sulphur and arsenic, and particularly of unmetallic earth. The connexion of these matters, is also much stronger in pyrites than in ores, and they are accordingly much harder; so that almost every pyrites can strike sparks from steel. From this property of striking sparks from steel, they have been called pyrites, which is a Greek word signifying fire-stone. Pyrites was formerly used for fire-arms, as we now use flints; hence it was called carbine stone. It is still named by some marcasite. Perhaps no other kind of natural body, has received so many names. Persons curious to know the other names less used, than those we have mentioned, may find them in Henckel's Pyritologia. We think, with that celebrated chemist, that the subject has been perplexed, by this multiplicity of names; for before his great and excellent work, the notions concerning pyrites, were very confused and inaccurate.

Pyrites differs also from ores, by its forms and positions in the earth. Although pyritous minerals generally precede, accompany, and follow veins of ores; they do not, properly speaking, themselves form the oblong and continued masses, called veins, as ores do, but they form masses sometimes greater, and sometimes smaller, but are always distinct from each other. Large quantities of them are often found unaccompanied by ores. They are formed in clays, chalks, marls, marbles, plasters, alabasters, slates, spars, quartz, granites, crystals; in a word, in all earths and stones. Many of them are also found in pitch-coals, and in other bituminous matters.

Pyrites is also distinguishable from ores, by its lustre and figure, which is almost always regular and uniform, externally or internally, or both. Some ores, indeed, like those of lead, many ores of silver, and some others, have regular forms, and are in some manner crystallized: but this regularity of form is not so universal, and so conspicuous in ores as in pyrites. The lustre of pyrites seems to be caused by its hardness, and the regularity of its form, by the quantity of mineralizing substances, which it contains.

By all these marks we may easily, and without analyses, distinguish pyrites from true ores. When we see a mineral that is heavy, possessed of metallic lustre, and of any regular form, the mass of which appears evidently to be entire, that is, not to have been a fragment of another mass, and which is so hard, as to be capable of striking sparks from steel, we may be assured, that such a mineral is a pyrites, and not an ore.

The class of pyrites is very numerous, and extensive. They differ one from another, in the nature and proportions of their component parts, in their forms and in their colours. The forms of these minerals are exceedingly various. No solid, regular or irregular, can easily be conceived, that is not perfectly imitated, by some kind of pyrites. They are spherical, oval, cylindrical, pyramidal, prismatic, cubic; they are solids with 5, 6, 7, 8, 9, 10, and more sides. The surface of some is angular, and consists of many bases of small pyramids, while their substance is composed of these pyramids, the points of which all unite, in the centre of the mass.

Pyritous minerals differ also in their component substances. Some of them are called sulphureous, martial, cupre-

ous, arsenical, as one or other of these substances predominates. We must observe with Henckel, whose authority is very great on this subject, that in general all pyrites are martial, as ferruginous earth is the essential, and fundamental part of every pyrites. This earth is united with an unmetallic earth, with sulphur or arsenic, or with both these matters; in which case the sulphur predominates over the arsenic, as Henckel observes. He considers these, as the only essential principles of pyrites, and believes, that all the other matters, metallic or unmetallic, which are found in it, are only accidental; among which he even includes copper, although so much of it exists in some kinds of pyrites, that these are treated as ores of copper, and sometimes contain even 50 lbs. of copper each quintal. Many other metals, even gold and silver, are sometimes combined in pyrites; but these are less frequent, and the precious metals, always in very small quantities; they are therefove justly to be considered as accidental to pyrites. The different substances composing pyrites, sensibly affect its colours. Henckel distinguishes them in general, into three colours, white, yellowish, or a pale yellow, and yellow. He informs us, that these three colours are often so blended one with another, that they cannot be easily distinguished, unless compared together.

The white pyrites contain more arsenic, and are similar to cobalt and other minerals, abounding in arsenic. The Germans call them mispickle, or mispilt. Iron and arsenic form the greatest part of this pyrites. As arsenic has the property of whitening copper, some pyritous minerals almost white, like that of Chemnitz in Misnia, are found to contain 40 lbs. of copper per quintal, and are so much whitened by the arsenic, that they are very like white pyrites. But Henckel observes, that these pyritous matters are very rare, and are never so white, as the true white pyrites, which is only ferruginous and arsenical.

Yellowish pyrites is chiefly composed of sulphur and iron. Very little copper and arsenic are mixed with any pyrites of this colour, and most of them contain none of these two metallic substances. This is the most common kind of pyrites: it is to be found almost every where. Its forms are chiefly round, spherical, oval, flattened, cylindrical; and it is composed internally, of needles or radii, which unite in the centre, or in the axis of the solid.

Yellow pyrites, receives its colour from the copper and sulphur, which enter into its composition. Its colour, however, is inclined to a green, but is sufficiently yellow, to distinguish it from the other two kinds of pyrites, particularly when they are compared together. To make this comparison well, the pyrites must be broken, and the internal surfaces must be placed near each other. The reason of this precaution is, that the colour of minerals is altered, by exposure to the air.

Persons accustomed to these minerals, can easily distinguish them. The chief difficulty is, to distinguish white pyrites from cobalt and other minerals, which also contain some copper, and mnch arsenic.

Hence then we see, that arsenic is the cause of whiteness in pyrites, and is contained in every pyrites of that colour; that copper is the principal cause of the yellow colour of pyrites, and that every pyrites which is evidently yellow, contains copper; that sulphur and iron, produce a pale yellow colour, which is also produced by copper and arsenic; hence some difficulty may arise, in distinguishing pyrites from its colours. We may also observe, that sulphur and arsenic, without any other substance, form a yellow compound, as we see from the example of orpiment, or yellow arsenic. Thus, althongh the colours of the pyrites, enable us to distinguish its different kinds, and to know their nature at first sight, particularly when we have been accustomed to observe them; yet we cannot be entirely certain, concerning the true nature of these minerals, and even of all minerals in general, that is, to know precisely the kinds and proportions of their component substances, but by chemical analyses and decomposition.

Beside the above-mentioned matters, which compose pyrites, it also contains a considerable quantity of unmetallic earth, that is, an earth which cannot by any process be reduced to metal. Henckel, Cramer, and all those who have examined this matter, mention this earth, and prove its existence.

We ought to observe, that this earth is combined, with the other principles of the pyrites, and not merely interposed between its parts. It must, therefore, be distinguished from earthy and stony matters, mixed accidentally with pyrites, and which do uot make a part of the pyrites, since they may be separated by mechanical means, and without decomposing that mineral: but the earth of which we now treat, is intimately united, with the other constituent parts of the pyrites, is even a constituent part of the pyrites, and essen-

tial to the existence of this mineral, and cannot be separated, but by a total decomposition of it.

According to Henckel, this unmetallic earth abounds much in the white pyrites, since he found from the analyses, which he made, that the iron, which is the only metal existing in these pyrites, is only about one-twenty-sixth part of the fixed substance, that remains after the arsenic has been expelled, by torrefaction or sublimation.

A much larger quantity of iron is in the pale yellow pyrites, according to Henckel. The proportion of iron, is generally about twelve pounds, to a quintal of pyrites, and sometimes fifty or sixty pounds: this is therefore called martial pyrites. It contains about one-fourth of its weight of sulphur, and the rest is unmetallic earth.

The quantity of unmetallic earth, contained in the yellow or cupreous pyrites, which are also martial, since, as we have observed, iron is an essential part of every pyrites, has not yet been determined. They probably contain some of that earth, though perhaps less of it, than the others.

The nature of this unmetallic earth of pyrites has not been well examined. Henckel thinks, that it is an earth disposed already by nature, to metallization, but not sufficiently elaborated, to be considered as a metallic earth. See the articles Metals and Metallization. This opinion is not improbable; but as alum may be obtained from many pyrites, may we not suspect, that this unmetallic earth, is of the nature of alumine? See Alum and Earths, Alumine. Perhaps also this earth is different, in different kinds of pyrites. The subject deserves to be well examined.

Although pyrites is not so valuable as true ores, because in general it contains less metal, and but exceedingly little, of the precious metals; and because its metallic contents, are so difficult to be extracted, that, excepting cupreous pyrites, which is called pyritous copper ore, it is not worked for the sake of the contained metal; yet it is applied to other purposes, and furnishes us with many useful substances; for, from it, we obtain all our green and blue vitriols, much sulphur, arsenic, alum, and orpiment. See the principal processes, by which these substances are extracted from pyrites, under Ores, and the respective articles.

As every pyrites contains iron, and most of them contain also sulphur; as the pyrites most frequently found, contains only these two substances, with the unmetallic earth; and as iron and sulphur have a singular action upon each other, when they are well mixed together, and moistened; hence many kinds of pyrites, particularly those which contain only the principles now mentioned, sustain a singular alteration, and even a total decomposition, when exposed during a certain time, to the combined action of air and water. The moisture gradually penetrates them, divides, and attenuates their parts; and the sulphur is acidified, attacks the martial earth, and also the unmetallic earth, and forms, with the fixed principles of the pyrites, different salts; so that a pyrites, which was once a shining, compact, very hard mineral, becomes in a certain time, a grayish, saline, powdery mass, the taste of which is saline, austere, and styptic.

Lastly, if this mass be lixiviated with water, crystals of sulphat of iron, and sometimes of alum, according to the nature of the pyrites employed, may be obtained by evaporation, and crystallization.

This alteration and spontaneous decomposition of pyrites is called efflorescence and vitriolization; because the pyrites become covered with a saline powder, and because vitriol is always formed. This vitriolization is more or less quickly accomplished in pyrites according to its nature. It is a kind of fermentation excited by moisture amongst the constituent parts of these minerals; and it is so violent in those which are most disposed to it, that is, in the pale-yellow pyrites, which contain chiefly sulphur and iron, that when the quantity of these is considerable, not only a sulphureous vapour and heat may be perceived, but also the whole kindles and burns intensely. The same phenomena are observable, and the same results are formed, by mixing well together and moistening a large quantity of filings of iron and powdered sulphur; which experiment Lemery has made, to explain the causes of subterranean fires and volcanoes.

We cannot doubt, that, as the earth contains very large masses of pyrites of this kind, they must undergo the same changes when air and moisture penetrate the cavities containing them; and the best natural philosophers agree, that very probably, this surprising decomposition of pyrites is the cause of subterranean fires, of volcanoes, and of mineral waters, sulphuric, aluminous, sulphureous, hot and cold.

No other pyrites is subject to this spontaneous decomposition, when exposed to humid air, but that which is both martial

and sulphureous, that is, the pale-yellow pyrites. The arsenical pyrites, or that which contains little or no sulphur, is not changed by exposure to air. This latter kind is harder, heavier, and more compact than the former. The pyrites which is angular and regularly shaped, is chiefly of this kind. Wallerius, in his Mineralogy, proposes to distinguish this kind of pyrites by the name of marcasite. When cut, it may be polished so well as to give a lustre almost equal to that of diamonds: but without refracting or decomposing the light; for it is perfectly opake. It was employed some years ago in the manufacture of toys, as of buckles, necklaces, &c., and is called in commerce marcasite. See WATERS, *Mineral*, and ORES.

PYROLIGNEOUS ACID.—In the destructive distillation of any kind of wood, an acid is obtained, which was formerly called *acid spirit of wood*, and since pyroligneous acid In distilling cork, however, it appeared to Fourcroy and Vauquelin, that the acid obtained resembled the acetous; and on pursuing the investigation they ascertained, both analytically and synthetically, that the pyroligneous acid is nothing more than the acetous contaminated with an empyreumatic oil produced from the wood.

This acid is obtained in large quantities by the distillation of wood in cast iron cylinders, which is done for the purpose of charring the wood for the mancfacture of gunpowder. It is conveyed by means of pipes into a suitable receiver, and is used largely in some manufactories in preparing the iron liquor. Dr. Bollman recommends it as a substitute for vinegar.

PYROTECHNICS.—The art of making fire-works. In this art the chief objects are to produce a st eam of fire, or an explosion. Gunpowder included in a strong paper implement affords the latter effect; the fiery stream is produced by mixing the ingredients of gunpowder together in different proportions, and pulverizing them without wetting. These burn more slowly than grained gunpowder. A sky-rocket is formed by ramming this composition into a paper tube, to which an arrow or tail is connected. The explosive stream gives the rocket a progressive motion by its reaction. Rockets are sometimes used in war; but as they are most commonly exhibited for mere amusement, it is usual to include gunpowder in the head of the rocket with balls of a still more slowly burning compound, with additions to vary the colour they exhibit at the instant of the explosion, and for a few seconds afterward.

Lights are also made for signals and station-marks. But as all these objects are in some measure remote from the explanation of scientific chemistry, the reader is referred to treatises written expressly on this art. See ROCKET.

Q.

QUARTATION, a method of separating gold from silver. See ASSAYING, and GOLD.

QUARTZ, a siliceous stone, comprehending several sub-species, as crystallized quartz, or rock crystal, fibrous, granular, and compact quartz.

Several of the varieties of crystallized quartz are used as seal stones and ornaments of various kinds, on account of their hardness, the exquisite polish that they are capable of receiving, and the pleasing tone of their colours. The most perfectly transparent and colourless is called by the lapidaries *rock crystal;* and besides being applied to various purposes of ornament, it is cut into spectacle glasses, which, from their hardness, are not so liable to be scratched as those which are made of flint glass. The reddish purple, or violet coloured variety, is called *amethyst*, and is occasionally ranked among the gems: it must not, however, be confounded with the oriental amethyst, which is a true gem, being a variety of corundum. The pearl gray, or pale blue variety, is called false, or *water sapphire*. The yellow and smoke coloured varieties are called *false topaz*. The green varieties are not unfrequently mistaken for chrysolite.

The granular quartz is used largely in the manufacture of china ware; it it first calcined, which renders it opake and brittle, and afterwards pulverized. When flint stone, which is more generally used, cannot be procured, the granular quartz is next preferred. Our country abounds with all the varieties of siliceous stones, suitable either for flint making, glass making, or pottery.

QUERCITRON, or *Black-oak bark.*—

This bark is used largely in tanning, dyeing, &c., and has become a considerable article of exportation.

According to Dr Bancroft, the quercitron bark may be advantageously substituted for weld in the printing of linens; but it must be only simply infused in warm water, and only one part employed, instead of ten of weld.

To dye wool yellow, Dr. Bancroft advises, that a solution of tin and alum should be put into the bath with the quercitron. Silk ought to be treated in the same manner as with weld: if a very bright yellow be required, it must be prepared with a solution of tin.

It appears from some information, for which Berthollet was indebted to Mr. Brown, that many manufacturers of printed linens in England, at present prefer this bark to weld, because it is considerably cheaper, and the ground whitens more easily. Some find it advantageous to mix a certain proportion of decoction of weld with the quercitron bath, which should be exposed to only a gentle heat. Mr D'Ambourney asserts, that, to obtain the advantages set forth by Dr. Bancroft, the wool must be first prepared with solution of tin, and then his process followed. See Dyeing.

QUICKLIME. See Earths, art. *Lime*.

QUICKSILVER. See Mercury.

QUILLS.—Quills are the large feathers taken out of the end of the wings of geese, ostriches, crows, &c. They are denominated from the order in which they are fixed in the wing; the second and third quills being the best for writing, as they have the largest and roundest barrels. Crow quills are chiefly used for drawing.

Large quantities of quills have been yearly imported from Germany and Holland.

The goodness of quills is judged by the size of the barrels, but particularly by the weight; hence the denomination of quills of fourteen, fifteen, &c. loths: viz. the thousand consisting of twelve hundred quills, weighing fourteen, fifteen, &c. loths. The loth is a German weight, weighing something more than an ounce. Particular attention should be paid on purchasing quills, that they may not be left handed, that is, not out of the left wing.

To render quills firm as well as elastic, various modes have been contrived. The process is called *clarification*. The most simple means is to thrust the barrel into hot sand for a few minutes; afterwards it is pressed almost flat, by means of a penknife, and then rendered round between the fingers, by the assistance of a piece of leather, or woollen cloth; with which their exernal roughness may be easily removed by friction. If, however, a considerable number of quills is to be hardened, it will be advisable to set a vessel, containing a little water and alum, over the fire; as soon as the liquor begins to boil, the barrels only must be immersed for a minute, after which they may be suspended to dry. Good pens constitute an article of indispensible necessity in all departments of trade, commerce and literature, &c. Hence, it becomes an useful, if not important object, to be able to cut them according to the most approved rules. The reader, who is desirous of information on this head, may examine Mr. Wilkes's small tract, entitled, *The Art of Making Pens scientifically*, &c., in which plain directions are given to that effect, together with appropriate instructions for the management of the quill, pen-knife, hone, strop, and other other articles, connected with the art of *pen-making*.

QUINTESSENCE.—As the essence of any medicinal substance, or that in which its chief virtue resided, was supposed by the old chemists to be obtainable in a condensed form by distillation; so they imagined, that it was still farther condensed and purified by subsequent distillations. Hence they used the term quintessence, or result of the fifth distillation, to denote any thing thus brought to its highest degree of purity as they conceived. It is now obsolete.

R.

RACK. See ARRACK, DISTILLATION, &c.

RADICAL.—That which is considered as constituting the distinguishing part of an acid by its union with the acidifying principle or oxigen, which is common to all acids. Thus sulphur is the radical of the sulphuric and sulphurous acids. It is sometimes called the base of the acid, but base is a term of more extensive application.

RADICAL VINEGAR. See ACETIC ACID.

RAG-STONE.—The colour of this stone is gray; its texture obscurely lamellar, but the laminæ consist of a congeries of grains of a quartz appearance, coarse and rough. Its specific gravity is 2.779. It effervesces with acids, and gives fire with steel. It is used as a whetstone, frequently without the application either of water or oil.

Whence it comes to us we know not, but its appearance resembles the pumice in every respect except its density. Its component parts in Kirwan's tables, are 70 silex, 5 alumine, 25 carbonat of lime, and 5 iron, as he thinks. This differs from the ROWLEY RAG, which see.

RAGS, *Bleaching of*. See PAPER-MAKING.

RAILWAY.—On the 14th of August, 1799, a party deputed from the committee for conducting the concerns of the Grand Junction Canal, with other gentlemen, attended at Mr. Joseph Wilkes colliery, at Measham, in Derbyshire, (England) for the purpose of obtaining occular and satisfactory proof of the utility of the iron railways, previous to that company adopting them (which they have now done) in lieu of some portion of their line of canal. The result of the experiments was nearly thus: one horse, of the value of 20*l.* on a declivity of an iron road five-sixteenths of an inch at a yard, drew twenty-one carriages or waggons, laden with coals and timber, amounting, in the whole, to thirty-five tons, overcoming the *vis inertia*, repeatedly, with great ease. The same horse, up this acclivity, drew five tons with ease; he also drew up the road, where the acclivity was 1 3-4 of an inch at a yard, three tons. But on this declivity it is necessary to slipper or lock the wheels, the horse not being able to resist the increased momentum of more than three or four tons.

The same gentlemen proceeded the next day to another colliery in Nottinghamshire, where one horse, value 30*l.*, drew, on a road of the same construction, where the declivity was one-third of an inch at a yard, twenty-one waggons, of five hundred weight each, which, with their loading of coals, amounted to forty-three tons, eight hundred weight; the same horse drew seven tons up the road. It must be observed, that in both the foregoing statements, the hundred weight is 120 lb. On this road the rails are three feet long each, 33 lb. weight, and calculated to carry two tons on each waggon, laid four feet two inches wide, on stone or wood sleepers, placed on a bed of sleck so as to fix it solid and firm. The expense of completing one mile of such a road, where materials of all descriptions lie convenient, and where the land lies tolerably favourable for the descent, will be about 900*l.* or 1000*l.* sterling per mile, single road, fenced, &c. exclusive of bridges, culverts, or any extra expense in deep cutting, or high embankments. Rails are made from twenty to forty pound per yard, agreeable to the weight they have to bear.

By the introduction of iron railways, constructed on the best plan, canals may extend their useful influence in enriching and improving the country to the distance of ten or twenty miles on either side of them, into high mountainous countries, where canals are almost impracticable: instance the railway of the Peak Forest, in Derbyshire, which joins the Ashton canal, the road from Denbigh to near the town of Derby, and a great many others. In numberless cases, near large towns, they would, no doubt, be of the greatest utility; as for Paddington and the Thames, to different parts of the metropolis, to convey merchandize to and from, as well as speedily and easily take off nuisances from the town, cause less wear to the streets, and prevent many disagreeable consequences arising from the great number of heavy burthened carriages crowding together.

In a great many instances it will occur, where a railway, either connected with a canal or not, will be the mode of a cheaper conveyance than water would be. It clearly appears, in the case of the Ashby canal, that their railway, which is now executing, and a double one, will cost two-thirds less than a canal would have

done in the district of their railway, where the ground for a canal is unfavourable, and furnish the article of lime, which it is principally intended to convey, at two-fifths less than a canal would have done, though it is an ascent for some miles on the road; so it is with the Peak Forest, Derby, &c. In short, wherever the quantity of goods to be conveyed on a railway, having a descent of not more than half an inch in a yard, amounts to two-thirds of the weight, as downgate loading, it is a doubt if it will not, in that case, be a cheaper conveyance than a canal: if dispatch is necessary, a railway is more certain than a canal, being far more easily repaired; neither does frost or dry seasons affect the trade thereon.

Iron railways have been used for some years in Shropshire, and other places; but for want of proper system in the forming and laying of such roads, they have been found of little or no more service than wood railways, which from the late improvements in iron roads, are now in disrepute.

The leading principles of iron roads are, that the ground should be formed true, making a perfect inclined plane, made dry by cutting back-drains, soughing, &c. Sleepers of stone, rather than wood, on which the rails rest, and which should be firmly fixed on a bed of stone, beat small, the horse-path filled with good small hard materials, rails three feet long each, weighing thirty-three pound, to carry two tons, and laid not less than four feet wide.

Iron roads, constructed on this plan, which is yet far short of the perfection they will arrive at, for the carriage of heavy goods to and from large commercial towns, in conjunction with canals, will evidently be of great national advantage; and if the turnpike roads were made on the concave system, the first principle of which is to have a perfect inclined plane, a considerable revenue might be derived by government therefrom, without a tax upon the public. Repairs would be very trifling, owing to water becoming the principal repairing agent; the traveller expedited from the smoothness of the road, and more secure from accident; the commerce of the country speedily conveyed from one point to another, and the farmer would be benefitted by the advantage of a rich wash, which might be easily conducted from the roads, over his fields, perhaps in many cases equivalent to the maintenance of the road.

The following account of the Penrhyn railway may be acceptable to many of our readers. The rail hitherto made use of in most railways is a flat one, three feet in length, with a rib on one edge, to give it strength, and to prevent the wheels (which have a flat rim) from running off. Observing that these rails were frequently obstructed by stones and dirt lodged upon them; that they were obliged to be fastened to single stones or blocks on account of their not rising sufficiently high above the sills, to admit of gravelling the horse-path; that the sharp rib standing up was dangerous for the horses; that the strength of the rail was applied the wrong way; and that less surface would create less friction; led Mr. Wyatt to consider, if some better form of rail could not be applied; the oval presented itself as the best adapted to correct all the faults of the flat rail, and he had the satisfaction to say that it has completely answered the purpose in a railway lately executed for Lord Penrhyn, from his lordship's slate-quarries, in Carnarvonshire, to Port Penrhyn. The wheel made use of on this rail has a concave rim, so contrived in its form, and the wheels so fixed upon their axis, as to move with the greatest facility in the sharpest curves that can be required. It is plain, by inspecting this rail, that no dirt can lodge upon it; that it must be stronger than any other form of the same weight, to resist both the perpendicular and lateral pressure; that it must occasion very little friction; that it presents no danger to the horse; and that it may be placed upon the sills, so as to admit of a sufficient quantity of gravel to cover them. These advantages have so forcibly struck all those who have seen and examined this road, that he has been induced to lay it before the public through the medium of the Repertory of Arts and Manufactures.

The Penrhyn railway is six miles and a quarter in length, divided into five stages. It has three-eighths of an inch fall in a yard, with three inclines; was begun in October 1800, and finished in July 1801.

On this railway two horses will draw twenty-four waggons one stage six times a day, and carry twenty-four tons each journey, which is 144 tons per day. This quantity used to employ 144 carts and 400 horses: so that ten horses will, by means of this railway, do the work of four hundred.

Mr. Fessenden remarks that, the preceding he hopes will meet with particular investigation from gentlemen who propose to embark property in cutting canals, and making locks to falls in our navigable rivers. If the advantages attending these

railways are equal to what is here represented, they ought, in most cases, to supercede canal and lock navigation.

Two horses would, on a conical iron road, convey a mail coach more than eight miles per hour as easy as the present mails are conveyed six miles per hour by four horses. The conveyance would be so easy, that gentlemen might read nearly as well as on board a ship. The even and compact manner in which this road would be laid, would render it the safest of all others, with the additional advantage of using wheels of any diameter. As this road might be kept constantly moist, it would have a singular advantage over other iron roads, in keeping the metal perfectly cool, and consequently less friction and wear. It has ever been an object in the projection of canals, to bring them as near towns as possible, when, after all, a cartage, or removal, must take place. In bringing a canal near a large town the difficulties and inconveniences are very great; valuable property is wasted, communication (which is very essential) is cut off, the situation for the business is limited, no further extension can take place; even this may be in a situation where there is an embankment, of course inconvenient to load in and out; or if deep cuttings, the wharves are then expensive in excavating. This railway would waste valuable land near a large town in a trifling comparative degree to a canal, communication would be free, on and over every part of the same; nor would there be any particular limited situation for wharves or warehouses: hence large towns would derive benefit in every part near which the road would be extended, carriages would not be liable to break down, nor would the wear of tires, or any part, be put out of order by violent shocks. The easy repairs of carriages on such a road will certainly bear no comparison to those on common roads. The iron railways in use, wherever they are upon, and cross a turnpike road, are inconvenient; these, on the contrary, form not the least impediment.

About the year 1768, a remedy was contrived for the principal objection to cast iron railways: namely, the making use of several small waggons linked together, instead of one large one; thus diffusing the weight over a greater surface of the road, and consequently throwing less stress on any one part of it. Soon after the year 1797, they began to be constructed as branches to canals: since that period they have rapidly increased, and their great utility is now unquestionably established.

As on canals, *locks* are required in order to raise the vessels from a lower to a higher level, and *vice versa;* so, on railways, what are called *inclined planes* are often necessary to attain the difference of level.

These inclined planes are generally, compared with the rest of the rail-way, very steep. A perpetual chain raises and lowers the waggons. It is so contrived, that the waggons disengage themselves the moment they arrive at the upper or lower extremity of the inclined plane. In some cases, the laden waggons descending serve as a power to bring up the empty ones; but where there is an ascending as well as a descending traffic on the railway, steam engines, water wheels, or other machines to answer the same purpose are used. At Chapel le Frith, there is an inclined plane about 550 yards long, so that the chain extended is, of course, more than double that length.

Most railways of considerable extent require the use of this species of machinery for attaining the difference of level requisite, more particularly in cases where minerals form any considerable part of the traffic. On the proposed railway between Glasgow and Berwick, several inclined planes will be required; the summit of that railway being 753 feet above the level of the end of Berwick quay.

The waggons are constructed on various plans, and are probably, in most cases, far from the degree of improvement of which they are susceptible. But, with all their disadvantages, the following facts will evince the great saving of animal force to which railways gave rise.

1. With 1 1-4 inch per yard declivity, one horse takes downward three waggons, each containing two tons.

2. In another place, with a rise of one inch and six-tenths per yard, one horse takes two tons upwards.

3. With eight feet rise in 66 yards, nearly 1 1-4 inch per yard, one horse takes two tons upwards.

4. On the Penryhn railway, (same slope as the above,) two horses draw downwards four waggons, each containing one ton of slate.

5. With a slope of 55 feet per mile, one horse takes from 12 to 15 tons downwards, and four tons upwards, and all the empty waggons.

6. At Ayr, one horse draws on a level five waggons, each containing a ton of coal.

7. On the Surry railway, one horse, on a declivity, of one inch in ten feet, is said to draw thirty quarters of wheat.

RAIN. See METEOROLOGY.

RAISING OF WATER. See HYDRAULICS and ENGINE.

RAISINS, are grapes prepared, by suffering them to remain on the vine till they are perfectly ripe, and then drying them in the sun, or by the heat of an oven. The difference between raisins dried in the sun and those dried in ovens, is very obvious: the former are sweet and pleasant, but the latter have a latent acidity with the sweetness, that renders them much less agreeable.

The common way of drying grapes for raisins is to tie two or three bunches of them together while on the vine, and dip them into a hot lixivium of woodashes, with a little of the oil of olives in it. This disposes them to shrink and wrinkle; and after this they are left on the vine three or four days, separated on sticks, in an horizontal situation, and then dried in the sun at leisure, after being cut from the tree.

The best fruits of this description, are *sun* and *jar raisins*; which are imported from the southern countries of Europe, and also from the Asiatic provinces of Turkey. They yield an agreeable *wine*. For which purpose, let one cwt. of raisins be deprived of their stalks, chopped, and put into a wide, but not too deep, vessel: Two-thirds, or fourteen gallons of water, are now to be added, and the whole suffered to stand for fifteen days, being carefully stirred once every day. At the end of that period, the raisins must be strained, pressed, and the liquor obtained from them, poured into another vessel. The remaining third part, or seven gallons of water, should next be added to the fruit, thus pressed, and likewise stand for the space of one week. The liquor is then again to be strained, and the two *runnings* are to be poured into a barrel, capable of containing twenty-one gallons, together with a quart of brandy. In order to colour the wine, three quarters of a pound of refined sugar must be set on fire, and burnt into a little of the liquor, which ought to be added to the whole; and, as soon as the fermentation ceases, the barrel may be closed, and suffered to stand till its contents are ready for bottling....*Raisin-wine* is an agreeable, cooling liquor; but, if it be too often used, or in too large quantities, it is apt to occasion flatulency.

RANCIDITY.—The change which oils undergo by exposure to the air.

Fixed oil, exposed for a certain time to the open air, absorbs oxigen, and acquires a peculiar odour, an acrid and burnt taste, at the same time that it becomes thick and coloured. If oil be kept in contact with oxigen in a bottle, it becomes more speedily rancid, and the air is absorbed. Scheele observed the absorption of a portion of the air, before the theory was well ascertained. Oil is not subject to alteration in closed vessels.

It appears, according to the observation of Chaptal, that oxigen, combined with the mucilage, constitutes rancidity; and that, when combined with the oil itself, it forms drying oil.

The rancidity of oils is therefore an effect analagous to the oxidation of metals. It essentially depends on the combination of oxigen with the extractive principle, which is naturally united with the oily principle. This inference is proved by attending to the processes used to counteract or prevent the rancidity of oils.

When olives are prepared for the table, every endervour is used to deprive them of this principle, which determines their fermentation; and for this purpose various methods are used. In some places they are macerated in boiling water charged with salts and aromatics; and after twenty-four hours digestion they are steeped in clear water, which is renewed till their taste is perfectly mild. Sometimes nothing more is done than to macerate the olives in cold water; but they are frequently macerated in a lixivium of quick-lime and wood-ashes, after which they are washed in clear water.

But in whatever manner the preparation is made, they are preserved in a pickle impregnated with some aromatic plant, such as coriander and fennel. Some persons preserve them whole; others split them, for the more complete extraction of their mucilage, and in order that they may be more perfectly impregnated with the aromatics.

All these processes evidently tend to extract the mucilaginous principle, which is soluble in water, and by this means to preserve the fruit from fermentation. When the operation is not well performed, the olives ferment and change. Chaptal affirms, that, if the olives be treated with boiling water to extract the mucilage before they are submitted to the press, a fine oil will be obtained, without danger of rancidity.

When the oil is made, if it be strongly agitated in water, the mucilaginous principle is disengaged; and the oil may be afterward preserved for a long time without change. The author above mentioned preserved oil of the marc of olives, prepared in this manner, for several years in open bottles without any alteration.

The torrefaction, to which several mucilaginous seeds are subjected before the extraction of the oil, renders them less susceptible of change, because the mucilage has been destroyed.

Mr. Sieffert has proposed to ferment oils with apples or pears, in order to deprive rancid oils of their acrimony. By this means they are cleared of the principle, which had combined with them, but now becomes attached to other bodies.

Mucilage may therefore be considered as the principle of the rancid ferment.

RAPE-SEED OIL.—The following remarks may be noticed in this place.

Mr. Thevenard has published the following method of *purifying* this oil. He directs 1½ or 2 parts of concentrated sulphuric acid to be added to 100 parts of oil, and the whole to be perfectly incorporated by agitation: the fluid immediately becomes turbid, assuming a dark-green cast; and, in the course of three quarters of an hour, the colouring particles begin to collect in lumps. The agitation must now cease: and double the weight of oil of vitriol, diluted with pure water, should be added: in order to mingle these different ingredients, the stirring ought to be renewed for the space of half an hour; after which the whole may be left to settle for seven or eight days. At the end of that time, the oil will be found on the surface; on being gently drawn off, and filtered through cotton or wool, it will be almost entirely divested of colour, smell, and taste; so that it will burn clear, without any interruption. See Oil.

RASPBERRY, the Common, Bramble, Framboise Hind-Berry, or Raspis; *Rubus Ideaus*, L.--An indigenous plant growing in damp woods and hedges; in thickets, and gravelly places near rivulets: it flowers in the months of May and June. The fruit of this shrub, in a natural state, is fragrant, sub-acid, cooling, and very grateful: when used as an ingredient of sweet-meats, or fermented with sugar, and converted into wine, or vinegar, its flavour is greatly improved. The white berries are sweeter than the red, but they are generally more contaminated by insects. When eaten in any quantity, and occasionally held in the mouth, this fruit is said to dissolve tartarous concretions formed on the teeth; though, for such purpose, it is supposed to be inferior to strawberries. The young and fresh leaves of the common raspberry are eagerly eaten by kids. See Wine.

RATIFIA, is a fine spirituous liquor, prepared from the kernels, &c. of several kinds of fruit, particularly cherries and apricots, with an addition of spice and brandy.

Ratifia of cherries is prepared by burning the cherries, and putting them into a vessel, wherein brandy has been long kept: then adding to them the kernels of cherries, with strawberries, sugar, cinnamon, white pepper, nutmegs, cloves, and to twenty pounds of cherries, ten quarts of brandy. The vessel is left open ten or twelve days, and then stopped close for two months before it be tapped.

Ratifia is chiefly distilled by the French. See Distilled Spirits.

RAWLINSON'S COLOUR-MILL. See Mechanics.

RAZORS. See Cutlery.

REAGENTS, *in Chemistry*. See Tests.

REALGAR. See Arsenic.

RECEIVER.—Receivers are chemical vessels, which are adapted to the necks or beaks of retorts, alembics, and other distillatory vessels, to collect, receive, and contain the products of distillations.

Receivers ought to be made of glass, not only because this matter resists the action of the strongest and most corrosive substances, but also because, being transparent, it allows the operator to see through it, and to judge, by the frequency of the drops, whether the distillation proceed too fast or too slow, and also whether the quantity and nature of the substances which come over be such as are required.

Almost all receivers are a kind of bottles of different sizes, of a spherical form, the necks of which are cut short, and each of which is pierced with a small hole in its lateral or upper part, to give vent to the air or vapours which are too expansive. Receivers of this form are called balloons.

Some receivers are matrasses with long necks. These are generally adapted to the beaks of glass alembics. This long neck serves to keep the belly of the receiver, where the liquor is collected, at a proper distance from the fire.

Receivers have different forms for particular operations. Such are those which have two or three beaks, either to be adapted to other receivers, or to admit at the same time the necks of several distillatory vessels, when the intention of the operator is, that the vapours of different substances should meet in the same receiver. Such also are receivers for essential oils, which are very convenient for the distillation of these oils. To obtain the essential oil of aromatic plants, these plants must be distilled with water. The plant and the water are to be put toge-

ther into a cucurbit, and the water, which is to receive a boiling heat, rises in distillation, carrying with it the essential oil, which also has the property of rising with this degree of heat. See OILS.

As a large quantity of water must be employed, that the plant may always be kept immersed in the alembic, and consequently as a good deal of it rises in proportion to the oil, any receiver of ordinary size would be soon filled with water with a little oil floating upon its surface, and would require to be frequently changed; which would be very troublesome, and would occasion a loss of part of the oil.

These inconveniences are avoided by using receivers contrived purposely for such distillations. They are so made, that they are never full, but that the water runs out, and leaves the oil behind. They are a kind of glass cucurbits, which contract as they rise higher; so that their neck, or upper opening, is but nearly of a convenient size to receive the beak of the worm. These receivers have another opening about the middle of the swelling or belly; and to this opening is joined a glass tube, which bends and rises vertically along the outer part of the receiver, so as to be within two inches and a half as high as the upper opening. At this height the tube bends again towards the side opposite to the body of the receiver, to pour into another vessel the liquor which rises there. It forms the figure of 8.

When this receiver is to be used, it is to be placed vertically under the beak of the worm. During the distillation, the liquor rises to an equal height in the body of the receiver and in the crooked tube: when therefore the height of the liquor in the receiver becomes greater than the height of the tube, it must begin to flow from the mouth of this tube into another vessel placed on purpose to receive it: but as essential oils are either lighter or heavier than water, and as they are therefore always collected either above or under the water, and as the liquor which discharges itself through the tube is taken from the middle part of the receiver, therefore nothing but water can be evacuated at the mouth of the pipe, while the oil always remains in the receiver Thus, with such a receiver, we may distil without the trouble of changing the vessels; which is certainly very advantageous.

RECTIFICATION. By rectification is meant the exact purfication of certain substances, by means of distillation or sublimation.

This operation is necessary to disengage many chemical products or agents, from a mixture of extraneous matters, which destroy their purity. Thus, for instance, sulphuric acid, when first obtained from sulphat of iron, or from sulphur, is always mixed with a considerable quantity, either of sulphurous acid, or of superabundant water, which weakens it. It is separated from both these matters by a second distillation, in which they, being more volatile than the acid, are carried off; which second distillation is called concentration or rectification of sulphuric acid.

Also, when animal and vegetable matters are decomposed by distillation, all the portion of oil that is not volatile, contained in these substances, does not rise but with a degree of fire, so strong as to burn a part of them, and to raise along with them, a considerable portion of saline substances, which being mixed with the oily part, considerably alter its purity. To purify these oils, which from their burnt smell, are called empyreumatic, new distillations must be applied,in which by means of a less heat, the most volatile and purest part of these oils, is separated from the most empyreumatic and saline parts, which remain at the bottom of the retort: this is called the rectification of empyreumatic oils. See OIL.

The alcohol obtained by a first distillation of liquors, which have undergone the spirituous fermentation, is overcharged with a large quantity of water and light oil, which rise along with them in this first distillation. The product of this distillation has been called aqua vitæ. It is an ardent spirit, very far from the degree of dephlegmation and purity which alcohol ought to have, to render it fit for chemical operations, and for several compounds commonly used, such as perfumed waters and liqueurs for the table.— This spirit is to be purified by new distillations, slowly conducted with a gentle fire, and water-bath; by means of which the most volatile part, that always rises first with the least heat, and which is the true alcohol, is separated from the less volatile part, that remains in the alembic, and which contains the phlegm and oil of wine, by which the alcohol was rendered impure. The first liquor of these second distillations or rectifications, is called rectified spirit of wine. See ALCOHOL.

The volatile salts obtained in the decomposition of certain oily substances, as volatile alkalies, from decomposed animal matters, are always very impure, and spoiled by much empyreumatic oil, which

rises along with them. They are purified and disengaged, by subjecting them to new distillations or sublimations, with a well conducted heat. The same observation is applicable to muriat of antimony, artificial cinnabar, phosphorus, and to many other chemical products, which are always impure, when obtained by a first operation, and must therefore be purified by a second distillation or sublimation. All these second operations, intended merely to purify matters, are called rectifications. They are not generally attended with much difficulty. We shall not therefore, enter into the details of them; but we shall only observe, that all rectifications, are founded upon the same principle. They all consist in separating substances more volatile, from substances less volatile; and the general method of effecting this, is to apply only the degree of heat, which is necessary to cause this separation. See DISTILLATION and SUBLIMATION.

RED CHALK, or REDDLE, an ore of iron in the state of red oxyd, commonly used as a pigment.

RED LEAD. See LEAD.

RED COLOURS. See DYEING and COLOUR-MAKING.

RED INK, is usually prepared, by infusing four ounces of the raspings of Brazil-wood, and two drachms of pulverized alum, in equal quantities, namely, a pint of rain-water and vinegar, for two or three days; at the expiration of which time, the infusion is boiled over a moderate fire, till the third part of the fluid be evaporated. It is then suffered to stand, for three or four days, when it is filtered through blotting paper, and preserved for use, in close vessels. There is no occasion for adding gum arabic, which only tends to suspend impurities, while it changes the ink to a pale purple shade. Another mode of making red ink, consists in triturating the whites of four eggs, and a tea-spoonful of pounded lump sugar, with a similar quantity of spirit of wine, till they acquire an uniform consistence. Vermillion is then to be incorporated, in such a proportion as will produce a red colour of sufficient strength. The liquor must be kept in a well closed vessel, and agitated every time before it is used. See INK.

RED SAUNDERS, a dyeing or colouring drug. See DYEING.

REED, or ARUNDO, L. a genus of plants, comprising ten species: of which the following are the principal, namely:

The *arenaria*, (*Calamagrostis arenaria* of Dr. Withering) or Sea-Reed.

The *phragmites*, or common-reed, grows in rivers, lakes, ditches, and fenny or marshy situations, to the height of seven or eight feet: it is perennial, and flowers in the month of July. This species is employed for covering cottages and barns; for which purpose it is superior to every other indigenous vegetable, being incomparably more neat and durable. By previously soaking the reeds, in strong alum water, such a roof may be rendered fire-proof. They are also manufactured into screens, for sheltering young plants, from the cold winds; and may be usefully employed for cane-bottomed chairs. Farther, the common reed makes excellent weaver's combs, and is generally nailed across the frame of wood work, to serve as the foundation of plaistered walls, pillars, &c. From the dried roots of this plant, a very nutritive flour is easily obtained, which may be converted into wholesome and palateable bread. Its panicles are used, in Sweden, to impart a green colour to wool.

The *epigeois*, (*calamagrostis epigeios* of Withering) or wood reed, is perennial, grows in shady ditches, and moist situations, where it flowers in July. It is manufactured into *hassocks*, or thick mats, for churches.

The *calamagrostis* (*lanceolata* of Dr. Withering) small or hedge-reed, is likewise perennial; grows in moist shady hedges and meadows; where it flowers in the month of July. This species is remarkable for its beauty, and is an ornament to ditch-banks and hedges. Professor Pallas, observes, that the panicles of the small reed, before the flower expands, impart a beautiful bright-green colour to wool, when boiled, with the addition of alum.

REFINING, is a term used in chemistry and several arts, to signify the purification of some substance, particularly of metals, as golds, silver, copper, iron, &c.

We shall here treat only of the refining of gold and silver; and for the refining of other substances, we refer to their several articles.

Gold and silver may be refined, by several methods, which are all founded on the essential properties of these metals, and acquire different names according to their kinds. Thus for instance, gold, having the property which no other metal, not even silver, has of resisting the action of sulphur, of antimony, of nitric acid, of muriatic acid, may be purified by these agents, from all other metallic substances, and consequently may be refined. These operations are distinguished by proper names, as purification of gold by antimo-

ny, parting, concentrated parting, dry parting. In a similar manner, as silver has the property, which the imperfect metals have not, of resisting the action of nitre, it may be refined by this salt; but the term refining is chiefly applied to the purification of gold and silver, by lead in the cupel

The refining of gold and silver, by lead in the cupel, is performed by the destruction, vitrification and scorification, of all the extraneous and destructible metallic substances, with which they are alloyed.

As none but the perfect metals can resist the combined action of air and fire, without being oxided, and thus changed into earthy or vitreous matters, incapable of remaining any longer united, with substances in a metallic state; there is a possibility of purifying gold and silver, from all alloy of imperfect metals, merely by the action of fire and air; only by keeping them fused, till all the alloy is destroyed: but this purification would be very expensive, from the great consumption of fuel, and would be exceedingly tedious. Macquer says, he has seen silver alloyed with copper, exposed longer than sixty hours to a glass-house fire, without being perfectly refined: the reason of which, is that when a small quantity only, remains united with gold or silver, it is covered and protected, from the action of the air, which is necessary for the combustion of the imperfect metals, as of all combustible matters.

This refining of gold and silver, merely by the action of fire, which was the only method anciently known, was very long, difficult, expensive, and imperfect: but a much shorter and more advantageous method, has been discovered. This method consists in adding to the alloyed gold and silver, a certain quantity of lead, and in exposing afterwards this mixture to the action of the fire. Lead is one of the metals, which are most quickly and easily oxided: but at the same time, this metal has the remarkable property, of being very easily melted, into a vitrified, and powerfully vitrifying matter, called litharge.

The lead, which is to be added to the gold and silver to be refined, or which happens naturally to be mixed with these metals, produces in their refining, the following advantages:

1. By increasing the proportion of imperfect metals, it prevents them from being so well covered and protected, by the perfected metals.

2. By uniting with these imperfect metals, it communicates to them a property it has, of being very easily oxyded.

3. Lastly, by its vitrifying and fusing property, which it exercises with all its force, upon the oxyded and naturally refractory parts of the other metals, it facilitates and accelerates the fusion, the scorification, and the separation of these metals. These are the advantages procured by lead, in the refining of gold and silver.

The lead, which in this operation is scorified, and scorifies along with it the imperfect metals, separates from the metallic mass, with which it is then incapable of remaining united. It floats upon the surface of the melted mass, because it loses also part of its specific gravity: and lastly it vitrifies.

These vitrified and melted matters, accumulating more and more, upon the surface of the metal, while the operation advances, would consequently protect this surface from the contact of air, which is absolutely necessary for the scorification of the rest, and would thus stop the progress of the operation, which could never be finished, if a method had not been contrived for their removal. This removal of the vitrified matter, is procured either by the nature of the vessel, in which the melted matter is contained, and which being porous absorbs and imbibes the scorified matter, as fast as it is formed; or by a channel, cut in the edge of the vessel, through which the matter flows out.

The vessel in which the refining is performed is flat and shallow, that the matter which it contains, may present to the air the greatest surface possible.— This form resembles that of a cup, and hence it has been called cupel. The furnace ought to be vaulted, that the heat may be applied upon the surface of the metal, during the whole time of the operation. Upon this surface a crust or dark-coloured pellicle, is continually forming. In the instant, when all the imperfect metal is destroyed, and consequently the scorification ceases, the surface of the perfect metals is seen, and appears clean and brilliant. This forms a kind of fulguration or coruscation. By this mark the metal is known to be refined. If the operation be so conducted, that the metal sustains only the precise degree of heat necessary to keep it fused, before it be perfectly refined, we may observe, that it fixes or becomes solid, all at once in the very instant of the coruscation; because a greater heat, is required to keep silver or gold in fusion, when they are pure, than when alloyed with lead.

The operation of refining, may be performed in small or large quantities, upon the same principles, but only with some differences in the management.

Large quantities of silver is thus purified, after the operations by which that metal is obtained from its ores. This silver, being always much alloyed, is to be mixed with a sufficient quantity of lead, to complete its purification, unless lead has been added, in its first fusion from the ore, or unless it has been extracted, from an ore which also contains lead ; in which latter case it is alloyed naturally, with a sufficient quantity, or more than sufficient, for the refining of it. See Ores of Silver. One of the ores of this kind, which is treated in the best manner, is the ore of Ramelsberg in Saxony. The several operations, which are practised in this country abounding in mines, and excellent metallurgists, have been exactly described by Schlutter. We shall here give a sufficient extract, of the method of purifying large quantities of silver, from Hellot's translation of Schlutter's work.

The workmen give the name of *the work* to the lead containing silver, obtained by smelting the ore of Ramelsberg. The first operation, called fining, upon this mass of lead and silver, is performed in a furnace called a reverberatory furnace, from the vaulted form, which makes the heat reverberate, upon the surface of the metal. This furnace is so constructed, that the flame of the wood, which is put into the fire-place, through a hole called the fire-hole, is directed, so as to circulate over the work within the furnace. The flame is thus directed by a current of air, which is introduced through the ash-hole, and passes out at an opening made at the side of the place, where the work is. The wood is considerably saved by this direction of the flame. In the furnace a large cupel or test, is to be disposed. This test is to be made with ashes of beech-wood well lixiviated, that the salt may be washed from them.

In some foundries, different matters are added to the ashes, as sand, lime, clay, calcined spar, or gypsum. We may observe, concerning these additions, that they would be very injurious, and would make the test melt, if a strong heat were applied ; but the heat requisite for fining, is only moderate.

When the test is well prepared and dried, all the work is to be put into it at once, which is generally sixty-four quintals : the fire is then to be made in the fire-place, with faggots ; but the fusion is not to be too much hastened, first, that the test may have time to dry thoroughly, which is very essential; for if any moisture remained when the metal is melted, an explosion might happen : secondly, because the work of the ore at Ramelsberg, and of most others, is rendered impure, by the mixture of many metallic matters, which ought to be separated, otherwise they would spoil the litharge, and give a bad quality to the lead afterward obtained, from that litharge. These extraneous matters, found in the work of Ramelsberg, are, copper, iron, and matt. As these substances are hard and refractory, they do not melt so soon as the work, if the heat be moderate; and besides, as they are specifically lighter, than the mixture of lead and silver, they float upon the surface of these two metals when melted, in form of a pellicle or skin, which is to be taken off. These impurities are called the scum or dross. The remainder forms also a scum, which appears when the work has received more heat, but before the litharge has began to form. This is a scoria, which is to be carefully taken off, and is called the second dross.

When the operation is come to this point, it is to be continued by means of bellows, the air of which is directed not on the wood, but on the surface of the metals, by means of iron plates, placed for that purpose, before the blast hole, and which are called papillons. This air is not intended to increase the fire, but to facilitate the combustion of the lead, and to push the litharge to a channel, in the opposite side of the test. This channel, is called the way of the litharge, because through this passage all the litharge, which is not imbibed by the test, flows out of the furnace. The litharge which is found in the middle of the largest lumps is friable, and crumbles into powder like sand. It is put into casks, each of which contains five quintals of it, and is sold by the name of saleable litharge. The quantity of this is about one-half or one-third of the whole litharge, that is formed. It is used for various purposes, and particularly for glazing earthen ware. The other part which remains, is called cold litharge. It is remelted, and reduced to lead. This fusion is called cold fusion, and the lead produced from it, called cold lead, is good and saleable, when the work has been well purified, from the extraneous matters mentioned above. The tests impregnated with litharge, are added to the same kind of ore when smelted ; because they contain not only much litharge, which

may be reduced to lead, but also some silver, in all refinings, whether in the large or small way, as Mr. Tillet observes.

When about two-thirds of the work are converted into litharge, no more litharge is formed: the silver is then covered with a sort of white skin, which the refiners call lightening: and they call the metal lightened silver or fined silver. The silver thus fined is not pure; every marc of it, contains about four gros of lead: the purification of it, is completed in the ordinary method; that is, by a second cupellation with a hotter fire; which latter purification is called refining, and the persons who perform it, are called refiners. The workmen employed in this first operation, or fining, give improperly the name lightening, to the white skin formed on the surface of the silver, when brought only to a certain degree of fineness; for we know that in assays, the lightening or coruscation above mentioned, does not appear, but when the silver is perfectly fine, or at least as fine as it can be made by cupellation.

A fining of sixty-four quintals of work of Ramelsberg, yields about eight or ten marcs of fine silver, thirty-five or forty quintals of litharge, that is, from twelve to eighteen of saleable litharge, from twenty-two to twenty-three of cold litharge, from twenty to twenty-two quintals of tests, and six or seven quintals of dross. This operation lasts from sixteen to eighteen hours.

If the silver (before these operations) were alloyed by gold, it retains this gold still after the fining and refining. The gold, if the quantity be considerable enough, may be separated by parting. The operations for the purification of gold by cupellation, are perfectly the same as those of silver. If the gold to be fined contains silver, this silver remains with it after the operation, because both these metals resist the action of lead. The silver may afterward be separated by parting.

REFRIGERATORY.—A refrigeratory is a copper vessel soldered round the capital of the alembic. Its use is to contain cold water, which is to be renewed when it is heated, and the hot water is to be let out at a cock fitted to the refrigeratory for this purpose. The intention of this renewal of the water of the refrigeratory, is to keep perpetually cool the capital of the alembic, that the vapours of the liquor which rise in distillation may be condensed more easily and more quickly.

These refrigeratories were much used formerly, and all alembics were furnished with them; but modern distillers find that this vessel is not attended with the advantages it was formerly believed to possess; for the distillation cannot succeed unless the capital of the alembic be as hot, or almost as hot, as the cucurbit. Mr. Baumé observed, that, when the capital was cooled by very cold water, the distillation was soon stopped, and did not again begin till the capital was considerably heated.

The refrigeratory has for these reasons been much neglected, and a worm substituted in place of it, which is indeed a kind of refrigeratory, but different from the other in this respect, that it is adapted to the nose of the alembic, instead of surrounding the capital.

This remedy, appears, however, to be in some measure inadequate, because the head produces a considerable return of spirit, even without a refrigeratory. It seems, nevertheless, that the inconvenience of this last addition arises merely from the large aperture of the neck. See Alcohol.

REGISTER.—Registers are openings in different parts of furnaces, which are to be shut occasionally with stoppers of burnt clay. By means of registers we may govern the fire as we please; for, by opening or shutting them properly, we may not only increase or diminish the activity of the fire, but also we may apply its action more to one part of the furnace than another, by giving direction to the current of air, which passes through it.

Notwithstanding the utility of registers, they are too much neglected. Many chemists have disused registers, probably because they did not find the advantages from them which they expected. The reason of this is, that registers have hitherto been ill made. Their principal fault is, that they are generally too small. A register cannot have its proper effect, unless it have an opening of two, three, or four inches for a furnace, the internal diameter of which is a foot; but we frequently see furnaces of eighteen or twenty inches in diameter, with registers, the openings of which are scarcely eight or ten lines. Besides, some who use furnaces are far from understanding their construction.

REGULUS.—The name regulus was given by chemists to metallic matters when separated from other substances by fusion. This name was introduced by alchemists, who, expecting always to find gold in the metal collected at the bottom of their crucibles after fusion, called this metal, thus collected, regulus, as containing gold, the king of metals. It was afterward applied to the metal extracted

from the ores of the semimetals, which formerly bore the name that is now given to the semimetals themselves. Thus we had regulus of antimony, regulus of arsenic, and regulus of cobalt.

RENNET, or *Runnet*, is the stomach of calves, or more properly is the coagulated milky substance which is found in the stomach of calves, which have received no other nourishment than the maternal milk. On the use of rennet, see CHEESE, and MILK.

RESOLUTION OF FORCES. See MECHANICS.

RETORTS, are vessels used in distillation. They are formed of glass, metal, or earthen ware. See DISTILLATION.

RETINASPHALTUM. See BITUMEN.

RHODIUM.—A new metal discovered among the grains of crude platina by Dr. Wollaston. The mode of obtaining it in the state of a triple salt, combined with muriatic acid and soda, has been given under the article PALLADIUM. This may be dissolved in water, and the oxide precipitated from it in a black powder by zinc.

This oxide exposed to heat continues black; but with borax it acquires a white metallic lustre, though it remains infusible. Sulphur, or arsenic, however, renders it fusible, and may afterwards be expelled by continuing the heat. The button, however, is not malleable. Its specific gravity appears to exceed 11.

Rhodium unites easily with every metal that has been tried, except mercury. With gold or silver it forms a very malleable alloy, not oxidated by a high degree of heat, but becoming encrusted with a black oxide when slowly cooled. One sixth of it does not perceptibly alter the colour of gold, but it renders it much less fusible. Neither nitric nor nitro-muriatic acid acts on it in either of these alloys: but if it be fused with three parts of bismuth, lead, or copper, the alloy is entirely soluble in a mixture of nitric acid with two parts of muriatic.

The oxide was soluble in every acid Dr. Wollaston tried. The solution of muriatic acid did not crystallize by evaporation. Its residuum formed a rose-coloured solution with alcohol. Muriat of ammonia and of soda, and nitrat of potash, occasioned no precipitate in the muriatic solution, but formed with the oxide triple salts which were insoluble in alcohol. Its solution in nitric acid likewise did not crystallize but silver, copper, and other metals precipitated it.

The solution of the triple salt with muriat of soda, was not precipitated by muriat, carbonat, or hidrosulphuret of ammonia, by carbonat or prussiat of potash, or by carbonat of soda. The caustic alkalies, however, throw down a yellow oxide, soluble in excess of alkali; and a solution of platina occasions in it a yellow precipitate.

The title of this product to be considered as a distinct metal has been questioned; but the experiments of Dr. Wollaston have since been confirmed by Descotils.

RHODIUM LIGNUM, *Rose wood.*---A wood or root brought from the Canary islands, and confounded with *aspalathus*, a simple, of considerable esteem among the ancients, but which has not come to the knowledge of latter times.

The writers on botany and the materia medica are much divided about the lignum rhodium, and not only with regard to the plant which affords it, but likewise in their accounts of the drug itself. This confusion seems to have arisen from an opinion, that the rhodium and aspalathus are the same; whence different woods brought into Europe for the unknown aspalathus, were sold again by the name of rhodium.

As to aspalathus, the ancients themselves disagree; Dioscorides requiring by this appellation the wood of a certain shrub freed from the bark, and Galen the bark of a root. At present we have nothing under this name in the shops. What was heretofore sold among us as aspalathus, were pieces of a pale-coloured wood brought from the East Indies, and more commonly called calambour.

The lignum rhodium of the shops is usually in long crooked pieces, full of knots, which, when cut, appear of a yellow colour like box, with a reddish cast: the largest, smoothest, most compact, and deepest coloured pieces should be chosen; and the small, thin, or pale ones rejected. The taste of this wood is slightly bitterish, and somewhat pungent; its smell very fragrant, resembling that of roses: when long kept, it seems to lose its smell; but on cutting, or rubbing one piece against the other, it smells as well as at first. Distilled with water, it yields an odoriferous essential oil, in very small quantity. Rhodium is at present in esteem only upon account of its oil, which is employed as a high and agreeable perfume in scenting pomatums and the like. It is likewise said to be much employed by rat catchers, either to entice the rats to the traps, or to cover the smell left by handling them. But, if we may reason from analogy, this odoriferous simple might be advantageously applied to nobler purposes; a tincture of it in alcohol,

which contains in small volume the virtue of a considerable quantity of the wood, bids fair to prove a serviceable cordial, not inferior perhaps to any thing of this kind.

RICE. On the means of making bread from rice alone. From the *Journal des Sciences, des Lettres, et des Arts*.

The art of making bread from rice, though much spoken of, seems to be very little understood. In Chomel's Dictionary it is said, that bread may be made of rice, but there is no accóunt of the means by which it is to be done. The book called *La Maison Rustique* goes rather further; for, it informs us, that this kind of bread is made by mixing together the flour of rye, and that of rice. The first of these books, therefore, may be considered as saying nothing, since it is absolutely impossible to make bread of the flour of rice (which is harsh and dry, like sand or ashes) by treating it in the manner in which wheat flour is treated. The manner of using rice flour described in the second book, is but an uncertain remedy in case of want; for, if we have no rye, we cannot, according to that book, make use of rice flour for making bread, because an equal quantity of rye flour is said to be necessary for that purpose; and consequently, in countries where no rye is grown, it would be impossible to make bread of rice, however great the want of bread might be.

The first thing to be done to the rice is to reduce it into flour: this may be done by grinding it in a mill, or, if we have not a mill, it may be done in the following manner. Let a certain quantity of water be heated in a saucepan or cauldron; when the water is near boiling, let the rice we mean to reduce into flour, be thrown into it: the vessel is then to be taken off the fire, and the rice left to soak till the next morning. It will then be found at the bottom of the water, which is to be poured off, and the rice put to drain upon a table placed in an inclined position. When it is dry, it must be beat to powder, and passed through the finest sieve that can be procured.

When we have brought the rice into flour, we must take as much of it as may be thought necessary, and put it into the kneading trough in which bread is generally made. At the same time we must heat some water in a saucepan, or other vessel, and, having thrown into it some handfuls of rice, we must let them boil together for some time: the quantity of rice must be such as to render the water very thick and glutinous. When this glutinous matter is a little cooled, it must be poured upon the rice flour, and the whole must be well kneaded together, adding thereto a little salt, and a proper quantity of leaven. We are then to cover the dough with warm cloths, and to let it stand that it may rise. During the fermentation, this paste (which, when kneaded, must have such a proportion of flour as to render it pretty firm) becomes so soft and liquid, that it seems impossible it should be formed into bread: it is now to be treated as follows.

While the dough is rising, the oven must be heated; and, when it is of a proper degree of heat, we must take a stew-pan, of tin or copper tinned, to which is fixed a handle of sufficient length to reach to the end of the oven. A little water must be put into this stew-pan, which must then be filled with the fermented paste, and covered with cabbage, or any other large leaves, or with a sheet of paper. When this is done, the stew-pan is to be put into the oven, and pushed forward to the part where it is intended the bread shall be baked; it must then be quickly turned upside down. The heat of the oven acts upon the paste in such a way as to prevent its spreading, and keeps it in the form the stew-pan has given it.

In this manner pure rice bread may be made; it comes out of the oven of a fine yellew colour, like pastry which has yolk of eggs over it. It is as agreeable to the taste as to the sight, and may be made use of, like wheat bread, to put into broth, &c. We must, however, observe, that it loses its goodness very much as it becomes stale

It may be here remarked, that the manner in which Indian corn is used in France for making bread, can only produce (and does in fact produce) very bad dough, and of course very bad bread. To employ it advantageously, it should be treated like rice, and it may then be used, not only for making bread, but also for pastry.

Rice is, in the opinion of Dr. Cullen, preferable to all other grain, both for its abundant produce, and the large portion of nutriment it affords. Hence, different methods have been devised, of cooking or dressing it in the most economical manner. Thus, if a quarter of a pound of rice be tied loosely in a cloth capable of holding five times that quantity, and then slowly boiled, it will produce above a pound of solid food; which, eaten with sugar, or boiled milk, forms a very palatable dish. And, if an egg, together with a quarter of a pint of milk, a small quantity of sugar, and grated nutmeg be added, it will afford a more agreeable pudding than those prepared either of wheat-

en flour or bread. One of the best preparations of this grain, however, especially for invalids, is its mucilage or *jelly;* which may be obtained by boiling two ounces of fine rice flour with a quarter of a pound of lump sugar, in a pint of water, till it become an uniform gelatinous mass: on being strained through a cloth, and suffered to cool, it constitutes a salubrious and nourishing food.

ROASTING OF ORE. See Ore.

ROASTING, an operation of cookery. Without troubling our readers with unnecessary remarks, we shall here make a few extracts from Count Rumford's work on this subject. By a reference to that work, cuts of the roasting machine may be seen. The Count observes, that "no process of cookery is more troublesome, or attended with a greater waste of fuel, than roasting meat before an open fire. Having had occasion to fit up a large kitchen, for the military academy at Munich, I was led to consider this subject with some attention, and I availed myself of the opportunity which then offered, to make a number of experiments, from which I was enabled to construct a machine for roasting, which upon trial, was found to answer so well, that I thought it deserving of being made known to the public; accordingly, I caused two roasters to be constructed in London, one at the house then occupied by the *Board of Agriculture*, and the other at the *Foundling Hospital*, and a third was put up, in *Dublin*, at the house of the *Dublin Society*. All these were found to answer, and they were often imitated. Meat roasted by this new process, is more delicate, more juicy, and higher flavoured, than when roasted on a spit before an open fire. Many roasters have been put up in the houses of persons of the highest rank; others in the kitchens of artificers, of public schools, taverns, and other houses of public resort, and the use of them has been found to be economical, and advantageous in all respects. The body of the roaster is a hollow cylinder of sheet iron, which, for a roaster of a moderate size, may be made about 18 inches in diameter, and 24 inches long; closed at one end, and set in an horizontal position in a mass of brick work, in such a manner that the flame of a small fire, made in a closed fire place directly under it, may play all round it, and heat it equally and expeditiously. The open end of this cylinder, which should be even with the front of the brick work in which it is set, is closed either with a double door of sheet-iron, or with a door of sheet-iron, covered on the outside with a pannel of wood; and in the cylinder, there is an horizontal shelf, made of a flat plate of sheet iron, supported on ledges rivetted to the inside of the cylinder, on each side of it. This shelf is situated about three inches below the centre, or level of the axis of the roaster, and serves as a support for a dripping pan, in which, or rather *over which*, the meat to be roasted, is placed.

This dripping-pan, is made of sheet-iron, and is about two inches deep, 16 inches wide above, 15 1-4 inches in width below, and 22 inches long, and is placed on four short feet, or what is better, on two long sliders, bent upwards at their extremities, and fastened to the ends of the dripping-pan, forming, together with the dripping-pan, a kind of sledge; the bottom of the pan being raised by these means, about an inch above the horizontal shelf on which it is supported. In order that the pan, on being pushed into, or drawn out of the roaster, may be made to preserve its direction, two straight grooves are made in the shelf on which it is supported, which, receiving the sliders of the dripping-pan, prevent it from slipping about from side to side.

In the dripping-pan a gridiron is placed, the two bars of which are on a level with the sides or brim of the dripping-pan, and on this gridiron the meat to be roasted is laid; care being taken, that there be always a sufficient quantity of water in the dripping-pan to cover the whole of its bottom to the height of at least half or three quarters of an inch, for the parpose of receiving the drippings of the meat.

Mr. Frost, of Norwich, places a second shallow pan, made of tin, and standing on four short feet, into the first, and then places the gridiron which is to support the meat, in this second dripping-pan. As the water in the first keeps the second cool, there is no necessity for putting water into this; and the drippings of the meat, may, without danger, fall into it. When Yorkshire puddings, or potatoes, are cooked under roasting meat, this arrangement will be found very convenient.

The second dripping-pan must not touch the first, except by the ends of its feet; the bottom of the second must also be clear of the bottom of the first. The lengths and widths of the two pans above, or at their brims, may be equal, and the brim of the second may stand half an inch above the level of the brim of the first. The horizontal level of the upper surface of the gridiron, should not be lower than the level of the brim of the second dripping-pan; and the meat should be so placed on the gridiron, that the drippings from it cannot fail to fall into the pan, and

never upon the hot bottom, or sides of the roaster.

To carry off the steam which arises from the water in the dripping-pan, and that which escapes from the meat in roasting, there is a steam tube belonging to the roaster, which is situated at the upper part of the roaster, commonly a little on one side, and near the front of it, to which tube there is a damper so contrived, as to be easily regulated without opening the door of the roaster.

The heat of the roaster is regulated at pleasure, by means of the register in the ash-pit door of its fire place, and by the damper in the canal, by which the smoke goes off into the chimney.

The dryness in the roaster is regulated by the damper of the steam tube, and also by means of the blow pipes.

These blow pipes, which lie immediately under the roaster, are two tubes of cast iron, about 2 1-2 inches in diameter, and 23 inches long, or about one inch shorter than the roaster; which tubes, by means of elbows at their farther ends, are firmly fixed to the bottom of the roasters, and communicate with the inside of it. The higher ends of these tubes come through the brick work, and are seen in front of the roaster, being even with its face. These blow pipes have stoppers, by which they are accurately closed; but when the meat is to be browned, these stoppers are removed, or drawn out a little, and the damper in the steam tube of the roaster being at the same time opened, a strong current of hot air presses in through the tubes into the roaster, and through the roaster into, and through the steam tube, carrying and driving away all the moist air and vapour out of the roaster. The hot wind blowing over the meat, causes that appearance and taste, which are peculiar to meat well roasted.

Directions for Roasters.

1. The fire place must be made very small. 2. Provision must be made for cleaning the flues when obstructed by soot.

For a roaster 18 inches wide, and 24 inches long, the fire place should be 7 inches wide, and 9 inches long; and the side walls of the fire place should be quite vertical to the height of 6 or 7 inches. The quantity of fuel requisite is incredibly small. A fire place of the above dimensions will contain coals enough to heat the roaster, and many more than will be necessary for keeping it hot when heated.

The soot flues may be 4 or 5 inches square, in the brick work, to introduce a brush like a bottle brush with a long handle; which openings may be closed with stoppers or fit pieces of brick or stone, and the joinings made good with a little clay. The stoppers may have a small iron ring or handle.

A simple contrivance is used for the purpose of removing the soot, which is apt to collect about the top of a roaster. By means of an oblong square frame constructed of sheet iron, and fastened to the top of the roaster by rivets, a door way is opened into the void space left for the flame and smoke between the outside of the roaster and the hollow arch or vault in which it is placed; and by introducing a brush with a flexible handle through this door way, the soot adhering to the outside of the top of the roaster, and to the surface of the brick work surrounding it, may be detached and made to fall back into the fire place, whence it may be removed with a shovel.

There should always be a passage, or throat of a certain length between the mouth or door of a closed fire place, and the fire place properly called, or the cavity occupied by the burning fuel. Where fire places are of large dimensions, it is very useful to keep this throat constantly filled with coal, which not burning, serves to defend the door from the heat of the fire; and being well warmed, inflames quickly.

In constructing closed fire places, for roasters, boilers, ovens, &c., it has been found to be a good rule to make the distance between the fire place door, and the hither end of the bars of the grate equal to the width of the fire place, measured just above the bars. In fire places of a moderate size, where double doors are used, it will suffice, if the distance from the hinder side of the inner door, to the hither end of the bars, be made equal to the width of a brick, or 4 1-2 inches; but if the door be single, it is necessary that the length of the passage from the door, into the place occupied by the burning fuel, should be at least 6 or 7 inches.

By taking away a large flat stone, or a twelve inch tile, placed edgeways, a passage may be opened occasionally, in order to clean out the canals, and remove the soot. The steam tube must open into a separate canal, which must be constructed for the sole purpose of carrying off the steam into the chimney, or into the open air. The steam tube must be laid on a descent, to convey off the condensed vapour.

Some care will be necessary in forming the vault, which is to cover the roaster above. Its form should be regular, in or-

der that it may be every where at the same distance from the roaster; and its concave surface, should be as even and smooth as possible, in order that there may be the fewer cavities, for the lodgement of soot. The distance between the outside of the roaster, and the concave surface of the vault, may be about two inches; and the same distance may be preserved below, between the brick-work and the sides of the roaster.

Directions for the Management of a Roaster.

1. Keep the roaster clean.

2. Prevent the meat from touching the sides, and the gravy from spilling. When grease-spots appear, the inside of the roaster must be washed, first with soap and water, then with pure water, to take away the soap, and wiped very dry.

3. The fire must be moderate; about one-third more time is required, than to roast in the usual way.

4. The blow-pipes must be closed, from the time the meat goes in, till within 12 or 15 minutes of its being sufficiently done, that is, till it is to be browned; which is effected in the following way: the fire is made to burn bright and clear, for a few minutes, till the blow-pipes begin to redden; (which may be seen by withdrawing their stoppers for a moment, and looking into them) when the damper of the steam-tube of the roaster being opened, and the stoppers of the blow-pipes drawn out, a certain quantity of air is permitted to pass through the heated blow-pipes, into, and through the roaster. The quantity of air necessary to be admitted, must depend upon the *trim of the roaster*, which will soon be discovered by the cook.

The damper of the steam-tube must be kept so much opened, that the steam from the meat and water, may not be seen coming out of the roaster, through the crevices of the door.

In brightening the fire, fresh coals must not be put in, but a small faggot of dry wood, or a little bundle of dry wood, split into small pieces. Indeed, wood is a preferable fuel to coals, for roasters. When the door of the roaster is to be opened, the steam-tubes and blow-pipes, must be first opened about a quarter of a minute, to drive away the steam.

To keep meat warm, when done, before it is sent to table; close the register of the ash-pit door, open the fire-place door, and damper in the chimney; take out the fire, or cover it with cold ashes, and lastly, open the dampers in the steam- and blow-pipes. When the heat is moderated sufficiently, the blow-pipes and the damper in the steam-tube, may be nearly closed; and if there be danger of the cooling being carried too far, the fire-place door may be shut.

The door may be made a little dishing, to prevent its warping, and should never shut into grooves, but close tight, by causing the flat surface, of the inside of the door to lay against, and touch in all parts, the front edge of the door-frame: which front edge must of course be made perfectly level, and as smooth as possible.

If the front end of the cylinder of sheet-iron, which forms the body of the roaster, be turned outwards over a very stout iron wire, (about one-third of an inch in diameter, for instance) this will strengthen the roaster very much, and render it easier to make the end of the roaster level, to receive this flat surface of its door; it can most easily be made level, by placing the cylinder in a vertical or upright position, with its open end downwards, on a flat anvil, and hammering the wire above-mentioned, till its front edge, which reposes on the anvil, is quite level.

In order that the roaster may close well, its hinges should be made to project outwards, beyond the sides of the roaster; and it should be fastened, not by a common latch, but by two turn-buckles, situated just opposite to the two hinges, and consequently the distance the two turn-buckles should be placed from each other, should be equal to half the diameter of the roaster.

The hooks for the hinges, and also the support for the two turn-buckels, should be situated at the projecting ends, of strong iron straps, fastened at one of their ends, to the outside of the roaster, by means of rivetting nails.

The door may be constructed of a single sheet of iron, and covered on the outside with a pannel of wood, not a board; or it may be constructed of two sheets of iron placed parallel to each other, at the distance of about an inch, and so fastened together, that the air between them may be confined.

This pannel consists of a square frame tenanted, and fastened together at each of its four corners with a single pin; and filled up in the middle with a square board or pannel, which is confined in its place, by being made to enter into deep grooves or channels, in the insides of the pieces which form the frame. The circular iron door to which the pannel is fixed, being covered and concealed from view by the wood, but its size and position are marked out by a dotted circle; and the heads

of ten rivets are seen, by which the wooden pannel is fastened to the iron door These rivets are made to hold the wood fast to the iron, by means of small circular plates of sheet iron.

The frame of the pannel consits of four pieces of common deal, four inches wide, and one inch thick, fastened with one pin only at each of their joinings at the corners, and these pins being situated in the centre of those joinings, if upon the frame, in the middle of each of the four pieces which compose it, a square be drawn in such a manner, that the corners of this square, may coincide with the centres of the four pins, which hold the frame together, as neither heat nor dryness makes any considerable alteration in the length of the fibres of wood, it is evident that the shrinking of the four pieces, which compose this frame, cannot alter the dimensions of this square, or in any way change its position. If, therefore, care be taken in fastening the pannel to the iron door, to place the riveting-nails, in the lines which form the four sides of this square, the shrinking of the wood, will occasion no strain on the iron door, nor have any tendency whatever to change its form; and with regard to the centre piece of the pannel, if it be fastened to the iron by two rivets,situated in the direction of the fibres of the wood, in a line dividing this piece into two equal parts, its shrinking will be attended with no kind of inconvenience. Care must be taken to make this pannel enter, so deeply into the grooves in its frame, that when it is shrunk as much as possible, its width shall not be so much reduced, as to cause it to come quite out of the grooves. This piece may be made about one-third of an inch thick; and the grooves which receive it, may be made of the same width, and about three quarters of an inch thick.

Cartridge-paper soaked in alum-water, is to be interposed between the iron door and wooden pannel, to prevent the wood being set on fire, from the heat of the iron: and each of the two rivets which pass through the centre piece of wood in the door, must also pass through a small block of wood, about an inch thick, which will give these rivets a proper bearing, without any strain to the iron door. The hinges are to be riveted to the outside surface of the circular iron door, and let into the wood. The turn-buckles must be made to press against the outside or front, of the wooden frame.

Of the Blow-pipes.

They should be of cast-iron, with flanches, and keyed on the inside of the roaster; and their joinings with the bottom of the roaster, must be made tight with some cement that will stand fire. A small quantity of iron-wire, put into the tubes, will increase their effect.

Of the Steam-tube.

It should be situated any where in the upper part of the roaster. The simplest damper is a circular plate of iron, a very little less in diameter than the tube, in which it moves on an axis, perpendicular to the axis of the tube. This axis being prolonged, comes forward through the brick-work.

Of the Dripping-pan.

It should be hammered out of one piece of sheet-iron; and a little shorter than the roaster; room must be left between the farther end of it, and the farther end of the roaster, for the hot air from the blow-pipes, to pass up into the upper part of the roaster. It should have two falling handles, one at each end, with stops to hold them fast.

To defend the bottom of the roaster from excessive heat, it occurred to me to use a shallow iron pan turned upside down, with a row of holes from side to side, at the farther end of it; and this invention was found to answer very well.

Roasting Ovens.

The general form of the front of the oven is circular; but it has two projections on opposite sides of it, to one of which the hinges of the door, and to the other the turn-buckles for fastening it when closed, are fastened. It has another projection above, which serves as a frame to the door-way, through which a brush is occasionally introduced for the purpose of cleaning the flues. On one side of this projection there is a small hole, through which the handle or projecting axis of the circular register of the vent-tube, (wich is not seen,) passes.

In the body of the oven, at the distance of half its semi-diameter, below its centre or axis, there is an horizontal shelf, which is fixed in its place, not by resting on ledges, but by its hither end being turned down, and firmly riveted to the vertical plate of iron, which I call the front of the oven. This shelf, which should be double, to prevent the heat from passing through it from below, must not reach quite to the farther end of the oven; there must be an opening left, about one inch in width, between the end of it and the farther end of the oven, through which opening the air heated below the shelf, will

make its way into the upper part of the oven.

The hollow space below the shelf, is intended to serve in place of the blow-pipes of a roaster; and this office it will perform tolerably well, provided means are used for admitting cold air into it, occasionally. This is done by means of a register, situated at the lower part of the vertical front of the roaster, a little below the bottom of the door.

The cylinder constituting the bottom of the oven is two feet long, and is supposed to be of cast-iron. It is cast with a flanch, which projects outwards, about one inch at the opening of the cylinder, by means of which flanch it is attached, by rivets, to the front of the oven, which, as I have already observed, must be made of strong sheet iron, near one-eighth of an inch in thickness.

The shelf, dripping pan, and double door might easily be made of cast-iron; and in case the shelf to save trouble of riveting, in making it double, may be covered by an inverted shallow pan, of cast-iron, and in the bottom of this pan, there may be cast two shallow grooves, both in the direction of the length of the pan, and about an inch from the sides, in which grooves, two parallel projections, at a proper distance from each other, cast to the bottom of the lower pan, may pass. These projections passing freely in the grooves which receive them, will serve to keep the dripping pan steady, in its proper direction, when it is pushed into, or drawn out of the oven.

To increase the effects of the air chamber, when this oven is used for roasting meat, a certain quantity of iron wire, in loose coils, or of iron turnings, may be put into the air chamber.

The door of the oven,should be about 19 inches in diameter within, or in the clear.

In fastening the vertical plate, which forms the front of the oven, to the projecting flanch, at the hither end of the oven, care must be taken, to beat down the heads of the riveting nails in front, otherwise they will prevent the door of the oven from closing, with that nicety which is requisite.

In setting this roasting oven, the whole of the thickness of the vertical front, should be made to project forward before the brick-work. The fire-place,doors, ash-pit, register-door, damper in the chimney, &c. should be in all respects, similar to those used for roasters; and the flues should likewise be constructed in the same manner."

ROCK OIL. See Petroleum, Bitumen.

ROCK SALT. See Salt.

ROCKETS. In the art of making fire-works, gunpowder constitutes the chief ingredient; but the proportion of it, is very frequently varied, according to the different uses for which it is intended. For making rockets, meal-powder only, is commonly employed, and mixed with an additional quantity of sulphur and nitre, according to the different purposes for which they are designed; on which account, the last ingredient is generally brought into the form of a powder, by solution and evaporation, during which latter operation, it is continually stirred.

The mechanical operations of the above-mentioned, are not belonging to this work, we shall only make mention of the different compositions, which are to be made upon chemical principles, as laid down by Wiegleb. For fuses, seven parts of meal-powder, five of nitre, and three of sulphur; and for rockets, thirty-six parts of nitre, eight of sulphur, and fourteen of charcoal, are to be taken in both these, the intention is, that the powder shall only be fired by degrees. For blue-balls are to be mixed together, thirteen parts of nitre, three of sulphur, seventeen-thirty-second parts of resin, seven-sixteenths of saw-dust, and nine-sixteenths of charcoal.—Light-balls require for the dry sort, two parts of nitre, one-half part of sulphur, three-sixteenths of resin, two-thirds of saw-dust, and one-half part of meal-powder; for the fusible, eight parts of sulphur, two of nitre, and four of meal-powder. Fire-balls are composed of twenty parts of corned powder, ten of pitch, six of nitre, four of sulphur, one of tallow, one of hemp, and two of linseed-oil. Water-rockets require eight parts of meal-powder, thirty-six of nitre, seven of sulphur, and one of resin. As these particular masses of fire, are destined to resist the air and water, and nevertheless to burn for a certain time, the oleaginous and combustible additions are requisite,among which, the intent of the saw-dust appears to be, to prolong the conflagration. Among these, also may be reckoned the Greek-fire, which in fact was not invented by a Greek, but by Callinicus of Helipolis, who is said to have used it, at the siege of Constantinople. It cannot be decided with certainty, what it properly was, or of what it was composed. According to the description of it given in history, it was a liquid substance, that was easily kindled, and extinguished with difficulty, which burned upon water, and was thrown enclosed in bottles and pitchers, into the enemies' ships, by which means they were set on fire. It is very probable, that pitch,

sulphur, linseed-oil, oil of turpentine, or petroleum, made a considerable part of its composition.

The variously coloured fire-works, depend on various additions, by which the natural colour of gun-powder, when on fire, may be altered, and in which metallic substances for the most part, such as antimony, zinc, marcasite, verdigrise, &c. are employed. Thus also, clean filings of iron produce what is called brilliant, or white fire.

ROMAN VITRIOL. See COPPER.

ROSE WATER. See DISTILLED WATERS.

ROSE OIL. See OIL.

ROSEMARY OIL. See OIL.

ROSIN, or more properly *Resin*.

This term is given to a very important class of vegetable substances, of which there is a great variety of species, differing from each other in consistence, colour, smell, and, in some degree, in chemical composition.

The origin of all the resins is the same, that is, they exude spontaneously, or are extracted by incisions made in the bark of the resinous trees, and most of them gradually harden by exposure to air. A further portion of the same resin may also be always extracted artificially from the tree that yields it, by chemical methods. Resin is also very generally met with in certain parts of vegetables, though its quantity is so small, or its combination with other constituent parts is so strong, as not to appear in its proper form till extracted by chemical analysis. Thus, the bark of the cinchona contains no inconsiderable quantity of resin, though none appears to the eye on mere inspection, or (probably) could be extracted by incision through the living tree.

The chemical properties which are usually understood to characterize a resin, are the following: it is first softened and then melted by heat, and when kindled, it burns readily with a strong and generally fragrant smell, with copious flame and smoke, and leaves scarcely any residue behind. It is insoluble in water and most watery liquids, and is not *easily* acted on by acids or alkalies, except they are concentrated, and the action assisted by heat or long digestion. But it readily and totally dissolves in alcohol, forming a clear, but coloured solution, from which by far the greater part of the resin is precipitated in a pulverulent form unaltered, by the addition of water, which immediately renders the solution opake and turbid. It is also soluble in sulphuric ether, and in the fixed and volatile oils; particularly the latter.

But though all resins agree in the qualities of inflammability, insolubility in water, and solubility in alcohol, there are several other circumstances which have usually been employed to distinguish the classes of resins.

Balsams, according to the ancient sense of the word, was certainly applied simply to those resins that always remained in a fluid or semi-fluid state, such as the balsam of Capivi, of Mecca, of Canada, &c.; and these appear to be resins holding a superabundance of essential oil, so that when distilled *per se*, a vast quantity of oil arises, and a hard brittle resin is left behind, if the heat employed is only moderate. Thus turpentine, which is a natural balsam, yields by distillation abundance of the essential oil of turpentine, and common rosin (which is a true resin) is left behind.

The term balsam, however, has of late been injudiciously applied in the modern chemical nomenclature to those two or three species of resins that contain a notable quantity of *benzoic acid*.

Gum resins are natural mixtures of a true resin with another substance apparently of the nature of gum, and soluble in water. Hence, if they are triturated with water, they remain suspended in it in pretty intimate mixture for a considerable time, forming an opake emulsive liquor. By standing, however, the resin subsides, and the liquor becomes clear, but it retains the flavour and smell of the gum resin, and leaves, on evaporation, a small quantity of brown extractive matter. Gum ammoniac is an example of this kind. This distinction, however, is not very precise, and is more useful in pharmacy than in pure chemistry.

There are some substances evidently resinous in their nature and origin, but which have other peculiar properties that have caused them to be excluded from the list of resins.

Camphor is of this kind, which possesses some distinctive characters that have already been fully described under that article.

Caoutchouc, copal, and perhaps amber also, appear to belong strictly to the class of resins, but each has some points in which it differs materially from them.

We shall refer our readers to the articles VARNISH, and TURPENTINE, for some of the most important individual resins.

We may conclude this article by a

short enumeration of the most important of the true resins, the gum resins, and the substances, not prepared by art, to which a resinous nature has been usually attributed. To attempt to enumerate them all would be endless, as there are few plants from which a species of resin may not be extracted by art, and even the number that exude spontaneously, is very great.

Though no classification will correctly correspond with their chemical properties, the limits between the resins and gum resins, not being very precise, we may usefully arange the greater part of these substances under the head of *Liquid Resins or Balsams*, *Solid Resins*, and *Gum Resins.* The two first classes are entirely or almost entirely insoluble in water, except they contain benzoic acid, but totally yield to alcohol. Distillation with water extracts from the liquid resins, a large quantity of essential oil, and leaves a residue much resembling the solid resins. The gum resins are partly soluble in water and partly in alcohol.

LIQUID RESINS.

1. *Turpentines.* Under this name we may include all the liquid resins exuding from the different species of pine, which from their importance in the arts, and the immense consumption of them, will be separately described under the article TURPENTINE. They all yield abundance of the limpid essential oil of turpentine when distilled, and by different modes of preparation furnish several varieties of *rosin*, *pitch*, *tar*, &c. There are at least four species of turpentines commonly known in the shops, the *Chio*, *Venice*, and *Common turpentine*, and the *Canada balsam.*

2. *Balsam of Capivi*, or *Copaiba*, is a clear yellowish resinous juice, about the consistence of thin treacle, which flows in considerable quantity from incisions made in the bark of a large tree of South America, the *Copaifera officinalis.*

This balsam has a very agreeable smell and a pungent bitterish taste. It grows stiffer by long keeping, but never concretes into a solid. It dissolves totally in alcohol. When distilled with water it yields nearly half its weight of essential oil, and a brittle inodorous resin is left. It appears, therefore, to be a natural combination, simply of resin and essential oil.

3. *Balsam of Mecca*, *Opobalsam*, or *Balsam of Gilead.* This is a liquid resin which exudes from the *Amyris opobalsamum*, a small evergreen tree that grows in many parts of the Levant, and also in great perfection on the shores of the Red sea. It bears an extremely high price among the Turks, who employ it chiefly as a cosmetic, and it is scarcely ever found genuine in any other part of Europe.

It is moderately fluid, of a yellowish white colour, very fragrant, and of a slightly bitter and acrid taste. Its chemical properties closely resemble those of the last mentioned species, and it is only mentioned in this place on account of the extravagant value which the Turks set upon it, which is far beyond that of all the other aromatics.

4. *Balsam of Peru.* This is a dark brown balsam, of the consistence of thin honey, obtained from the *Myroxylon Peruiferum* (as it is said) by boiling the twigs and bark in water, and, when cold, the balsam swims at the top of the liquor and is skimmed off. There appears to be two species of this balsam, the *white* and the *brown*, but the latter is the only one commonly known.

This juice has a very fragrant smell and pungent taste. It is entirely immiscible with water and with the fixed oils, but dissolves in the essential oils, and in alcohol. When this balsam has long remained at rest in any vessel, it deposits crystals, from which the benzoic acid may be obtained by sublimation.

By distillation with water, this balsam yields one-sixteenth of its weight of an essential oil, of a reddish colour, and a pungent taste. This oil probably also contains benzoic acid. When completely charred by sulphuric acid, Mr. Hatchett found 100 grains to yield 64 grains of mere charcoal. A compound tincture of this balsam forms the common *Friar's balsam*, used as an application in cuts and slight wounds.

5. *Balsam of Tolu.* This juice flows from incisions made in the trunk of the *Toluifera balsamum*, a large tree resembling the pine, which abounds in the province of Tolu, in South America. It is of a yellowish brown colour, and, when fresh, of a thick tenacious consistence, but by age it hardens so as to be moderately brittle in cold weather.

This balsam has a most fragrant smell, more so than most of the resins, somewhat resembling lemons. When chewed it clings to the teeth, and at first gives very little taste, but after a time it leaves an agreeable pungency in the mouth. When kindled, it burns with a copious flame and smoke (like all the other resins) but this is accompanied with a very pungent fragrant vapour which excites coughing, and is owing to the volatilization of the benzoic acid that this balsam contains in some abundance, though in much less proportion than the gum ben-

zoin. When this balsam is boiled with water it melts, and settles at the bottom of the vessel, and appears to remain there unaltered, but the water without losing its transparency becomes highly fragrant and pungent, and contains a notable quantity of benzoic acid. This acid may also be procured from it by the same methods by which it is extracted from the gum Benzoin, as described under that article.

Balsam of Tolu is totally soluble in alcohol, and it is entirely separated from this menstruum (the benzoic acid excepted) by water. If the solution is not too concentrated, this precipitated balsam remains for a time suspended in the liquor, and gives it a milky appearance. By distillation this balsam yields an essential oil and benzoic acid. A hundred grs. of the balsam, charred by sulphuric acid, gave fifty-four grs. of charcoal.

6. *Liquidambar*, or *Liquid Storax*. This is a resinous juice, which flows from the trunk of the *Liquidambar styraciflua*, a tree resembling the maple, found in Virginia and Mexico. This balsam is of the consistence of honey, reddish brown, nearly transparent, of an acrid, unctuous taste, and a fragrant smell. It is seldom seen, and has not been much examined.

Solid Resins.

7. *Gum Anime*. This resin, which is very rarely met with, exudes from the trunk of the *Hymenea courbaril*, a large tree growing in Brazil and New Spain. It is brought over either in small roundish tears, or in larger masses, with the surfaces covered with a white powder. The colour is yellowish white and pellucid; it is very brittle, and gives a shining fracture. It resembles *copal* in appearance, but is readily distinguishable from it, (among other things) by being easily and totally soluble in alcohol, which *copal* is not, without much difficulty and particular management. This resin has very little taste. It is insoluble in water, but forms a grateful yellow tincture with alcohol, which has a bitterish pungent taste. Distilled with water it gives a very small quantity of essential oil. The natives of the countries whence it is procured chew it, but it is never used in Europe.

8. *Benzoin*. This resin, which contains more of the benzoic acid than any other substance, has already been described under this article.

9, *Dragon's Blood*. The origin of this valuable resin is not precisely known, but it appears to be obtained from several large trees growing in many parts of the East Indies and the Indian Archipelago, of which the most known are the *Calamus rotang*, and *Pterocarpus draco*. This resin is very largely mixed and adulterated, so that the samples to be found in the different shops, often have scarcely any other resemblance than in colour. The best sort of dragon's blood is found in irregular roundish pieces about the size of a walnut, often wrapped in palm leaves, and of a deep uniform dull red colour, without smell or taste. When broken, its texture appears homogeneous, but evidently cellular. If a little of it is rubbed much in a mortar, the colour brightens, and somewhat approaches that of vermillion.

Pure dragon's blood is entirely insoluble in water, but totally soluble in alcohol, forming a tincture of a fine blood-red colour. It burns with a bright flame, and readily consumes, leaving only a small portion of a white ash. When charred by sulphuric acid, 100 grs. leave 48 grs. of coal.

Dragon's blood is soluble in the essential oils, and also in the fixed, giving them a fine red colour. This resin is largely used in *Varnishing*, (which see) in lacquering, and painting, where a full bodied deep red is wanted.

10. *Gum Elemi*. This resin comes over from South America in semi-pellucid yellowish masses, generally wrapped up in leaves, and visibly contaminated with bits of twigs and bark, friable in the fingers, softening by heat, of a fragrant smell, and bitterish taste. The tree that yields it is supposed to be the *Amyris elemifera*.

Water dissolves only about one-sixteenth of this resin, and the remainder is soluble in alcohol.

11. *Gum Hedera*, is a resin which exudes in hot countries from the stalks and leaves of the ivy (*Hedera helix*).

It appears in hard compact masses, reddish brown externally, internally of a bright yellow, nearly opake, brittle, and with a glossy vitreous fracture. The smell is agreeable when rubbed, the taste slightly astringent. It is not entirely soluble either in water or alcohol, so that in strictness it ought hardly to be called a true resin. It is little known, and has not been carefully examined.

12 *Labdanum or Ladanum*. This resin exudes spontaneously from the leaves and branches of a fragrant shrub (*Cistus Creticus*) which grows abundantly in the dry mountainous regions of the Isle of Candia, Syria, and other parts of the Levant. Ladanum is a black, hard, heavy, resinous mass, rough externally, and in

fragments, and its fracture shews distinct sparkling particles. When chewed it gives a gritty feel to the mouth, and a bitterish taste, but does not dissolve. The smell is fragant. When digested with water it imparts its grateful smell, but does not sensibly dissolve therein. By distillation it gives a fragrant essential oil, and a tasteless brittle resin remains. Alcohol dissolves all the resin, and always shews in the undissolved residue a considerable quantity of sand and other impurities.

13. *Mastich.* This very valuable resin is procured from the *Pistacia Lentiscus*, a tree that grows to ten or twelve feet high, and is cultivated in many parts of the Levant, particularly in the island of Chio.

The best mastich is in the form of small roundish tears, hard and brittle, of a faint yellow colour, nearly transparent, with a light but pleasant smell, and little or no taste. When chewed it softens in the mouth, and excites a considerable flow of saliva. It is nearly insoluble in water, but gives it a pleasant flavour when boiled with it. Alcohol and the essential oils dissolve mastich entirely, forming a clear light-yellow tenacious solution, which either alone or with other resins is much employed in varnishing and other arts. When charred by sulphuric acid, 100 grains afford 66 of charcoal.

14. *Sandarac.* This resin exsudes from the bark of several kinds of juniper, and concretes in nearly pellucid yellowish tears of a pleasant smell, and scarcely any taste.. It is completely soluble in alcohol, and in oils fixed or essential, and is much used in varnishing.

15. *Tacamahacca.* This resin is obtained from the *Fagara octandra*, a tree found in many parts of South America. There are two sorts of this resin; the best is collected in gourd shells, and is unctuous and soft, of a greenish yellow colour, a delightful smell approaching to that of lavender, and a bitterish aromatic taste. It is seldom used.

16. *Styrax*, or *Storax*, is a very fragrant resin procured from the *Styrax officinalis*, a middling sized tree, a native of Asia. There are two sorts of this resin; the Styrax calamita, composed of reddish brown masses of a waxy consistence, and free from visible impurities. The other, which is by much the commonest sort, is so largely adulterated with saw-dust, that it looks rather like a mass of saw-dust somewhat agglutinated by means of a soft clammy resin. Common styrax infused in water gives it a golden colour, a fragrant smell, and a slight balsamic taste. Distillation with water still further impregnates this liquid with the same qualities of smell and taste, and contains *benzoic* acid, which may be extracted in the way mentioned under this article. When styrax is distilled *per se* it yields along with an empyreumatic oil some crystallized flowers of benzoin. Alcohol dissolves all the true styrax from the impure mass. In flavour, and, when pure, in other properties, this resin strongly resembles the balsam of Tolu.

Gum Resins.

These substances, as already mentioned under this article, are not entirely soluble in either water or pure alcohol, singly, but completely so in a mixture of the two. Many of them have very strong sensible properties, and they are altogether much more active when used medicinally than the resins. When rubbed with water, they form a thick emulsion, from which most of the resinous part separates by repose.

The gum-resins are principally, though not entirely, used in medicine.

17. *Asafœtida.* This gum-resin is the dried juice of a large umbelliferous plant, (*Ferula asafœtida*,) which grows in the mountains of Persia and Arabia. It is collected by cutting the mature plant a little above the ground, which causes a quantity of white juice to exsude on the cut surface of the stock, that soon concretes into a brownish soft gum. This is removed, a fresh surface is made on the stalks by cutting it down for an inch or two, and more of the juice is collected, till after a time the whole is exhausted, and the stalk dies.

Asafœtida is brought to us in irregular masses mostly of a brownish colour approaching to red, and involving smaller lumps that are nearly white. It has a very strong fetid smell like garlic, extremely permanent and diffusive, its taste is nauseous and bitterish. If rubbed with water it entirely resolves into a milky emulsion, from which after standing for some time most of the resinous part subsides, leaving a clear supernatant liquor containing much gum in solution. Pure alcohol dissolves only the resinous part, and makes a clear yellow solution. Dilute alcohol dissolves the entire resin, and forms a brownish, rather turbid tincture. Water distilled off asafœtida rises strongly impregnated with its peculiar smell. A hundred grains charred by sulphuric acid yield 58 grains of charcoal.

18. *Galbanum* is the concrete gummy-resinous juice of an umbelliferous plant of Ethiopia. (*Bubon galbanum*,) and is brought over in pale semi-transparent, soft, tenacious masses, intermixed with

clear white tears of the same resin. This juice has a strong unpleasant smell, and a bitterish, warm taste. When rubbed with water, it dissolves into a milky emulsion, and has all other chemical properties of the gum resins.

19. *Gum Ammoniacum*, a gum resin brought from the East Indies, composed of small white lumps or tears, more brittle than most of the other gum-resins, and easily reduced to fine powder in cold weather. It unites perfectly with water into a milky emulsion, and water and alcohol separately dissolve only a portion of the gum. It is sometimes employed in a small degree in the composition of cements and varnishes. A hundred grains charred by sulphuric acid give 58 of charcoal.

20. *Opopanax* is a strong-smelling gummy resinous juice procured from the *Pastinaca opopanax*, and brought from Turkey and the East Indies in small round drops or irregular lumps of a reddish yellow colour. It mingles perfectly with water, and agrees in chemical properties with the other gum resins.

21. *Sagapenum*, is a fetid gum much resembling asafœtida, but weaker in sensible properties; it is brought from Alexandria, in soft irregular masses sticking to the fingers when handled. In chemical properties it agrees very closely with asafœtida.

22. *Olibanum*. A gum resin brought from Turkey and the East Indies, in large roundish lumps, semi-pellucid, and when of the purest kind, of a slight yellow colour. When chewed, it has a bitterish pungent taste, and makes the saliva milky. The smell is moderately strong, and not disagreeable. When laid on a hot iron, it burns with a strong, penetrating, and rather fragrant smell, and is supposed to have been used by the ancients for incense.

23. *Gamboge*. For a description of this valuable gum, see the article *Gamboge*.

24. *Euphorbium*, is a juice procured from a plant of this name, brought chiefly from Barbary, in drops of an irregular form of a pale yellow and brittle. This gum-resin has but little smell, but the taste is one of the most biting and acrid of any known substance, and the effect on the organs remains for a considerable time. It consists of about equal parts of gum and resin.

25. *Myrrh*. This gum-resin exsudes from a tree which grows in Abyssinia and many parts of Arabia, but is little known. It comes over in rounded pieces of various size, and still more varying in colour, consistence, taste, and smell. The best sort is semi-transparent, friable, unctuous to the touch, of a strong but not ungrateful smell, and a slightly pungent and very bitter taste. It burns with some difficulty. It completely dissolves in boiling water when previously pulverized, but on cooling, a yellow resinous sediment falls down. The supernatant liquor evaporated nearly to dryness yields a saponaceous extract, which retains much of the flavour of the myrrh. Alcohol digested with myrrh forms a very fine golden yellow colour, which is made turbid by the addition of water.

Guaiacum. This substance has usually been reckoned among the perfect resins, but late experiments (though they are not complete) shew that it has some very peculiar properties, so that it cannot be classed properly either with the gums or resins.

This gum is procured from the *Guaiacum wood*, or *Lignum vitæ*, which is a very hard, ponderous wood, obviously abounding with resin, and as it were soaked in it, so that it has a peculiar greasy feel, and a very strong and peculiar smell when rubbed.

Gum guaiacum is brought over in irregular masses, easily friable, of a dusky green colour. It is in some degree transparent, and it breaks with a vitreous fracture. When pulverized, it is of a gray colour, but becomes green on exposure to air. It melts when heated, and gives a very pungent aromatic odour. The smell is fragrant; it gives scarcely any taste in the mouth, but when swallowed, it excites a strong burning sensation in the throat. Mr. Hatchett has observed that guaiacum, though apparently a pure resin, differs from all the pure resins in giving much oxalic acid by the nitric, and in yielding scarcely any artificial tannin with the nitric acid. Mr. Brande has since given an interesting analysis of this substance.

When pulverized guaiacum is digested in a moderate heat in distilled water, an opake solution is formed, which becomes clear on passing the filter. The liquor is of a greenish brown colour, and a sweetish taste. The muriats of alumine and tin, and nitrat of silver, all cause a brown precipitate, and when the liquor is evaporated an *extract* is left. One hundred grains of guaiacum yield about 9 grains of this extract, which also contains some salt of lime, as shewn by the oxalic acid.

Alcohol dissolves guaiacum with ease, leaving about 5 per cent. of extraneous matter undissolved. This solution is of a deep brown colour, and is decomposed by water, which separates the resin, and

leaves the liquor of a milky hue. If muriatic acid is added to the alcoholic solution, the resin at first separates, which an excess of the acid redissolves. The addition of nitrous ether to the tincture, and subsequent dilution with water, causes the resin to precipitate, which soon acquires a fine *blue* colour, and this change of colour appears characteristic of the resin of guaiacum, and has been employed as a means of detecting any adulteration. Liquid oxymuriatic acid added to the tincture, also precipitates the resin immediately of the same blue colour. Acetic acid causes no precipitate, the resin being readily soluble in this acid. Nitric acid, diluted with one fourth of its weight of water, turns the tincture green, and gives a green precipitate after standing for some hours, but the colour soon changes to blue, and afterwards to brown.

Alkalies do not cause any precipitation in the tincture.

ROSIN, *yellow*. See TURPENTINE.

ROTTEN-STONE. See TRIPOLI.

ROUCOU. See ANNOTTO.

ROUGE, *Ladies'*. See CARMINE, and COLOUR MAKING.

ROUGE, *polishing*.—This is a powder employed by goldsmiths to give the last polish to their work, which they commonly call colouring it. The finest is of a high red colour, and very soft to the touch. It is said to be a very pure native red oxide of iron. Sometimes it is of a red inclining to purple, and has the appearance of a very fine crocus martis: but this is of inferior quality. Chaptal asserts, that if pieces of old hat, in the dyeing of which iron is used, be immersed a few minutes in sulphuric acid, the iron will pass to the state of red oxide, and they will become excellent polishers.

RUM.—This liquid differs from simple sugar spirit in containing more of the natural flavour, or essential oil of the sugar cane; a great deal of raw juice, and parts of the cane itself, being fermented in the liquor of which it is prepared. The unctuous or oily flavour of rum is the effect of the natural flavour of the sugar cane.

The method of making rum is this:— When a sufficient stock of materials is got together, they add water to them, and ferment them in the common manner. When the wash is fully fermented, or to a due degree of acidity, the distillation is carried on in the common way, and the spirit is made up proof; though sometimes it is reduced to a much greater strength, nearly approaching that of alcohol, and is then called double distilled rum. It would be easy to rectify the spirit, and bring it to a much greater purity than we usually find it to be; for it brings over in the distillation a very large quantity of the oil, and this is often so disagreeable, that the rum must be suffered to lie by a long time to mellow, before it can be used; whereas, if well rectified, it would grow mellow much sooner, and would have a much less potent flavour. If the business of rectifying was more nicely managed, it seems very practicable to throw out so much of the oil as to have it in the fine light state of a clear spirit. In this state it would very near resemble arrac, as is proved, by mixing a very small quantity of it with a tasteless spirit.

Rum is usually very much adulterated. Some do it with malt spirit; but if done with molasses spirit, the tastes of both are so nearly allied, that it is not easily discovered. See ARRACK, ALCOHOL, BRANDY, DISTILLATION OF SPIRITS, &c.

RUST.—Oxydized iron is commonly so called. See IRON.

RYE. See AGRICULTURE.

S.

SAFFLOWER. *Carthamus, or Bastard Saffron.*

This plant, the flower of which is employed in dyeing and colouring, is cultivated in Spain, and in many parts of the Levant, from which it is chiefly imported.

This dyeing material, contains two colouring matters, a yellow and red, the former of these alone, is soluble in water, and is comparatively of little value, the latter is soluble in alkalies, and precipitated thence by several acids and forms, a beautiful rose-red pigment. This is partly used for silk dyeing, but the great consumption of it is in the *rouge*, so celebrated as a cosmetic, and of which it forms the essential ingredient.

To prepare the carthamus for this purpose, it is necessary first to extract the yellow portion, which is done by tying the plant in a linen bag, and then washing it incessantly with water, using much squeezing and rincing, till the water pass-

es off colourless. The residue in the linen bag, now consists of the fibrous part of the plant, and of the valued red fecula, which last however, is in very small quantity. This is extracted by digesting the washed carthamus, in a solution of carbonat of soda, (without applying artificial heat, which would impair the colour,) and this gives an orange yellow alkaline solution, which on saturation with acids turns red, and gradually deposits a beautiful red fecula, which is the pigment in question. Lemon juice is the acid preferred. But as the colour of this red fecula is extremely intense, it will bear dilutions, which is done chiefly by rubbing it with finely powdered talc, in different proportions.

Alcohol will also dissolve the red part of carthamus; and after the yellow portion has been extracted by water, a fine red tincture is made by digesting the residue in alcohol.

On account of the high price of carthamus, it is seldom, if ever employed, except for giving a finishing gloss to dyed silks, and for the preparation of rouge. Alkalies of every kind, immediately alter the colour, to an orange yellow, again restorable by acids. See Dyeing.

SAFFE. See Zaffe.

SAGO. The Sago-tree, *cycas circinalis*, grows spontaneously in the East Indies, and particularly in the Moluccas, and on the coast of Malabar.

This is a valuable tree to the inhabitants of India, as it not only furnishes a considerable part of their constant bread, but also supplies them, with a large article of trade. It runs up with a straight trunk, to forty feet or more. The body contains a farinaceous substance, which they extract from it, and make into bread.

The tree, which seems to grow merely for the use of man, points out the meal by a fine white powder, which covers its leaves, and is a certain indication, of the maturity of the Sago. The inhabitants then cut it down to the root, saw the body into small pieces, and after beating them in a mortar, pour water upon the mass; this is left for some hours to settle. When fit, it is strained through a cloth, and the finer particles of the mealy substance, running through with the water, the gross ones are left behind and thrown away. After the fecula is sufficiently subsided, the water is poured off, and the meal being properly dried, is occasionally made into cakes, and baked. These cakes, are said to eat nearly as well, as wheaten bread, and are the support of the inhabitants, for three or four months in the year.

The fecula being passed through perforated copper-plates, is formed into the grains called Sago. It forms an agreeable jelly, with water, milk, or broth, and is much used in phthisical and convalescent cases.

There is a sort of Sago brought from the West Indies, but far inferior in quality to that coming from the East It is supposed to be made from the pith, or areca oleracea.

SAL AMMONIAC. *Muriat of Ammonia. Salzaures ammoniak.* Germ.

This neutral salt, consisting of muriatic acid and ammonia, in a state of mutual saturation, was not unknown to the ancients. In the time of Pliny, it was imported into Europe from Egypt, and continued to be furnished by the same country, to the various states of modern Europe, till within the last fifty or sixty years. It has also been prepared in India (probably in the same manner as in Egypt) from time immemorial. Before treating of the properties of this salt, we shall give an account of its manufacture, first in Egypt, and then in the various countries of Europe.

On account of the great want of wood in Egypt, the principal fuel of the country is composed of the dung of camels, cows, and other domestic gramnivorus quadrupeds, mixed up with chopped straw, and dried in the sun. The soot produced by the combustion of this fuel, is the material from which sal ammoniac is prepared, by sublimation. The vessels made use of on this occasion, are very thin globular glass baloons, with a short neck terminating in a mouth about 1½ inch in diameter. The largest balloons are about 36 inches across, but they are of various sizes, being capable of containing when three-quarters full, from 12 to 50 lbs. of soot. In order to secure them as much as possible from breaking, during the process, they are coated with a mixture of mud, deposited by the Nile, and chopped straw.

It has been affirmed by the Jesuit le Pere Sicard, and some others, that the soot is mixed with a certain proportion of common salt, and camels' urine, but this appears to be a mistake; being absolutely contradicted by the most accurate enquirers. From these it appears, that no other ingredient is made use of, but soot, with which, moderately pressed down, the balloons are filled, to within about four finger's breadth of the neck. The vessels thus charged are arranged, to the number of 60 or 70, in an oblong furnace

of brick, and secured with clay, so that the necks alone are in contact with the external air. The furnace is now very gradually heated, by means of straw, for the first three or four hours, and afterwards, with a mixture of straw and the common fuel of the country, viz. dried dung. In the course of six or seven hours, a thick somewhat acid empyreumatic smoke, begins to rise out of the balloons, and continues for about fifteen hours.—The sublimation of the sal ammoniac commences three or four hours, before the smoke ceases, and continues from 15 to 40 hours, according to the size of the balloon, without any further care being required, than to regulate the fire properly, and to pass an iron rod occasionally down the necks of the balloons, to prevent them from being clogged up by the salt, as it rises, and thus producing an explosion. When the sublimation ceases, the fire is allowed to go out, and the vessels as soon as they are sufficiently cool, are removed from the furnace and broken; the cake of sal ammoniac, which occupies their upper part, is in the form of a very shallow bason, and weighs on an average somewhat more than one-seventh of the soot employed; it has generally a yellowish white tinge, and is apt to be fouled with a little charcoal, especially if the heat has been too great.

The proportion of salt, from a given quantity of soot, is liable however to considerable variation: it is found that the dung of the same animal, affords a soot much richer in salt, when it is fed on fresh vegetables, than on hay and other dry food. There is besides a great difference in the soot, from the dung of different animals, similarly circumstanced as to food. According to Mr. Granger, the Egyptian sal ammoniac makers, esteem the soot of cow-dung, when the animal is fed on grass, to be by far the best, 26 lbs. affording no less than 6 lbs. of salt. According to Hasselquist, however, the soot from the dung of goats and sheep, is in the highest estimation.

In this very simple manufacture, the sal ammoniac appears to exist ready formed in the soot, and the action of the heat, is confined to the mere separation of the saline, from the other ingredients. The soot itself is of a deep black colour, has very sensibly the taste of sal ammoniac, and when strongly heated, gives out a sulphureous odour.

In Europe, where dung is employed to no better purposes than for fuel, the manufacture of sal ammoniac, is a much more complicated process, especially when carried on in the best and most economical manner. A kind of intermediate method however, is practised with success, in some establishments in the Netherlands, of which the following are the principal details.

A kind of fuel capable of furnishing sal ammoniac by its combustion, is first prepared, the ingredients of which are,

Twenty-five parts by measure, of pulverized pit coal.

Five parts by measure, of common chimney soot.

Two parts by measure, of clay.

To these is added, a saturated solution of common salt, in sufficient quantity to bring the whole to a consistence, for being moulded into balls. The balls are of an oval form, and after being dried in the air, are ready for use.

The apparatus for collecting the soot, produced by the combustion of the fuel, consists of a brick furnace, communicating by a flue, two inches in diameter, with a vaulted chamber, also of brick, from the opposite extremity of which, there passes out a flue of the same diameter, as that already mentioned, terminating in a horizontal gallery, at the end of which is the chimney. The furnace is charged with the balls above mentioned, to which is added, a somewhat variable proportion of dry bones; and with these materials an incessant fire is kept up, for from four to six months. At the expiration of this time, the vaulted chimney and gallery are opened, and the soot with which they are lined is scraped off, from the top, the sides, and floor, observing to keep the soot from the latter, distinct from the rest.

The principal new combinations, that take place in consequence of the combustion, appear to be the following: first, the pit-coal is resolved into gas of various kinds, into empyreumatic oil, loaded with finely divided charcoal, and into carbonated ammonia: the soot forms carbonic acid, and also gives out the carbonated ammonia which it contained: the bones afford empyreumatic animal oil, and carbonated ammonia; and the common salt by the action of the clay, is decomposed, its alkaline base remaining united to the earth, and its acid passing in a gasseous state into the chamber, where it meets with and decomposes the carbonated ammonia, forming sal ammoniac. Hence the contents of the soot collected in the chamber, are carbonaceous matter, muriat of ammonia, and empyreumatic bituminous oil: the latter of which is particularly abundant, in the soot that concretes on the floor.

To separate the sal ammoniac from the other ingredients, sublimation is had

recourse to, and is thus performed. Several egg-shaped jars, made of earthenware, about 20 inches high, and 16 in diameter, with a mouth 2½ inches wide, are fixed in a furnace, and as soon as they are become moderately warm, are charged with soot, broken into small pieces, to within three inches of their mouths; a duly regulated heat is then kept up for 48 hours, in which time the volatile oil first rises, and passes out into the air, then the sal ammoniac sublimes, and fixes itself to the upper part of the jars, while the earthy and carbonaceous impurities remain at the bottom: the vessels are then broken, and the cakes of salt extracted. Fifteen pounds of soot afford on an average, about five pounds of muriated ammonia. The soot from the floor of the chamber, is too much loaded with bitumen, to admit of the salt being extracted from it, by simple sublimation, and the most economical way of treating it, is to burn it over again, by which the bitumen is destroyed, and the sal ammoniac mixed with the soot, rises uninjured into the chamber.

The method of carrying on the manufacture of this salt in England, though more complicated than the above, is, we apprehend, considerably more economical. The following was the actual practice, at a large establishment near London, which was abandoned a few years ago, in consequence of Glauber's salt being subjected to the excise.

The material from which the ammonia was extracted was bones. These were collected in the streets and from dunghills, chiefly by old women. The bones having been thus procured, were chopped into small pieces either by hatchets or machinery, and then boiled, in order to extract the grease or fat and marrow remaining in them, which was sold to the soap-boilers. The bones were then thrown into a cylindrical iron still, about 3 feet in diameter, and 8 or 9 feet long, laid horizontally over a fire-place, so as to be capable of being made moderately red-hot. At one end of the cylinder was a mouth about 14 inches in diameter, by which the bones were introduced, and furnished with a cover capable of closing it accurately by the help of a little lute. From the other end of the cylinder proceeded a cast iron pipe, from 6 to 8 inches in diameter, and 18 or 20 feet long, terminating in one or more oblong leaden receivers, which were kept cool by water, placed in a vessel of the same materials, the bottom of which formed their cover, the juncture being secured by lute. Of these receivers there were commonly two to each still, or three to two stills. Every receiver was about 12 feet long, 1 foot deep, and 14 inches wide, and the refrigeratory which covered it held about 4 inches in depth of water: at the end the most remote from the still was a pipe, fitted with a wooden plug for the purpose of drawing off the condensed liquor, and above this was a hole through which the gas and incondensible vapour passed off into the open air.

A single charge of each still yielded about 36 lbs. of impure alkaline liquor, and about 30 lbs. of black fetid oil floating upon its surface. This latter being skimmed off, the alkali was saturated with sulphuric acid, either by the addition of the mother liquor from the green vitriol makers (consisting for the most part of red sulphat of iron); or still more economically by means of calcined and pulverized gypsum: in this latter case, after mixing the materials, and stirring them well together, they are to be left at rest for some hours, during which a double decomposition takes place, the sulphat of lime yielding part of its acid to the ammonia, and at the same time depriving this latter of its carbonic acid. The solution of sulphat of ammonia thus produced is then mixed with common salt, by which another decomposition takes place, the alkali of the former and the acid of the latter uniting to form muriat of ammonia, while the two remaining ingredients produce by their combination sulphat of soda.

The liquor containing these two salts is then clarified by subsidence and decantation, and transferred into oblong leaden boilers, about 9 feet long, 3 wide, and 9 inches deep. The boilers are set for about two-thirds of their length on iron plates, heated by a fire beneath, the remaining part being supported by flat tiles defended by solid brick-work from the access of the heat. As the water evaporates the Glauber salt begins to crystallize, and is swept from time to time to the cool extremity of the boiler, whence it is shovelled out into baskets arranged over the end of the boiler, that the liquor which drains from the small granular crystals may not be lost. The evaporation is continued for several hours, till as much as possible of the Glauber's salt has been separated, and the muriat of ammonia begins to crystallize on the surface of the liquor in the form of feathered stars. The remaining liquor is then run off into coolers, and deposits little else than muriat of ammonia, till it gets below the temperature of 70° Fahr. at which time the crystals are to be removed, lest they should

be mixed with Glauber's salt, which now begins to be again deposited. After the muriat of ammonia has been suffered to drain in the baskets, it is removed to a kind of oven, or even an open tiled hearth heated from below, where the water of crystallization is driven off, by which the salt becomes spongy, friable, and of an ash or slate colour, interspersed with small white filaments.

The salt is now removed while hot into globular glass receivers, or more commonly glazed earthen jars, fitted with a cover (having a hole of above half an inch diameter in its centre) luted on with a mixture of clay and horse-dung These are set in iron pots over a strong fire, in a furnace of either a circular or oval form, and capable of containing from six to eighteen, surrounded with sand up to the edge of the pot, and also having about two and a half inches of sand on the cover, confined by an iron ring about three inches deep, and two inches less in diameter than the cover, in order that if the luting should give way in any part, it may be repaired without suffering the covers (which should be kept during the sublimation at about 320°) to be cooled by the removal of a large portion of the sand. These earthen pans may be filled to within two inches of the top, with the dried salt gently pressed in, but not rammed close; and the fire, which has been lighted some time before, is now to be raised gradually till the iron pots are of a pretty strong red heat all round, being so placed in the furnace that the upper part may be first heated, the bottom resting on solid brick-work. During the first impression of the heat, a portion of the salt carrying with it a quantity of watery vapour not separated on the drying place, will escape through the hole in the cover, which must be left open till all the aqueous particles are exhaled: this is known by bringing a piece of rol'd smooth iron plate near the hole in order to condense the sublimate, which, becoming more and more dry, at length attaches itself firmly to the plate, in the form of a dry semi-transparent crust. At this time the hole is to be stopped with a bit of lute, more sand is to be put on the cover, and the heat continued till it is judged that nearly the whole of the muriat of ammonia is sublimed. The time requisite for this purpose depends on the structure of the furnace, the size of the pots, the briskness of the fire, and other circumstances only to be learnt by experience. The process should be stopped before the sublimation has entirely ceased, as the heat in some parts of the jar may be too great when it is nearly empty, and either by burning a part of the salt itself, or elevating a portion of foreign matter from which it can never be kept wholly free, give the cake a yellow tinge, and a scorched, opake, crackled appearance. The same defects are likely to happen, when any part of the luting having given way, is obliged to be repaired by wet lute, when the sublimation is pretty far advanced: consequently glass vessels are preferable, except on account of the expense, as they must always be broken to pieces in order to get out the cake: the jars on the contrary will serve for several sublimations, even the covers, if well glazed, will last for two operations. The sublimation being finished, and the apparatus having become sufficiently cool, the tops of the jars are to be taken off, and the cakes of sal-ammoniac that are found adhering to them are to be separated, and placed for a day or two in a damp atmosphere, which softens their surface a little, and thus facilitates the removal of any superficial impurities. Lastly, the cakes are packed up in casks for sale.

The following is a table of the proportions of dry carbonat of ammonia afforded by different substances:

Horn - - -	1-fifth,
Feathers - -	2-elevenths,
Wool - - -	1-eighth,
Soot - - -	1-fifteenth,
Bones - - -	1-sixteenth,
Blood - - -	1-seventeenth,
Putrid urine -	1-forty-sixth.

In common manufactories the dry carbonat yields rather less than two-thirds of sal-ammoniac In most of the Scotch manufactories soot is used instead of bones, these latter being only to be procured abundantly in the vicinity of a very large town.

The water of composition contained in sal-ammoniac is the same in quantity according to Beaumé, whether the salt is sublimed, or crystallized from its aqueous solution. With this Mr. Kirwan agrees, who states the component parts of sal-ammoniac, whether sublimed or crystallized, at

42.75	Muriatic acid
25.	Ammonia
32.25	Water
100.00	

The uses of sal-ammoniac are considerable. Beside being employed in the laboratory as the substance from which pure and carbonated ammonia are pro-

cured, it is used in substance by the dyer, the refiner of gold, the copper-smith, and the manufacturer of tin-plate.

SAL GEM, is rock salt.

SAL MARTIS, is the green sulphat of iron. See Iron.

SAL POLYCHREST, is Sulphat of *Potash*, calcined with a very small portion of sulphur, formerly used in medicine.

SAL PRUNELLA, is Nitrat of *Potash*, from which the water of crystallization has been expelled by fusion.

SALEP.—The powder of the orchis root. The farina of potatoes is said to be an excellent substitute for salep, and less liable to spoil by keeping

SALT.—This term has been so variously applied, that it is scarcely possible to give an accurate definition of it. The general and the most antient idea of a salt is, a crystallizable substance, considerably soluble in water, and highly sapid; but the term is at present applied to all the crystallizable acids or alkalies, or earths, or combinations of acids with alkalies, earths, or metallic oxyds. Hence the common and useful distinction of the compounded salts into *alkaline*, *earthy*, and *metallic*. In so doing, however, and by including all the crystallizable combinations of acids and bases, some compounds have got the name of salts which want the primary, (and what would formerly have been considered as essential,) qualities of solubility and sapidity, of which sulphat of barytes is an example, which is absolutely insoluble in water and tasteless. It is still, however, crystallizable, or found crystallized, which appears to be an invariable character of a salt. Thus this appellation was long denied to carbonat of magnesia, till the discovery of the crystallizable soluble carbonat of this earth.

There are many triple combinations also of these ingredients, which belong to the class of salts, such as alum, tartarized antimony, &c.

Salts are also either *neutral* (that is, where the ingredients are in exact saturation) or with the acid in excess, of which tar is an example, or with an excess of the base, as in borax. These circumstances have been ingeniously distinguished in nomenclature by Dr. Thomson, by the prefix *super* in the first case, and *sub* in the latter. Thus tartar is named with propriety the *super-tartrite of potash*; borax, the *sub-borat of soda*, &c.

The term *salt* is also used emphatically for common salt, or muriat of soda.

SALT, *Bitter*, *Purging*, or *Epsom*. See Epsom Salt.

SALT, *Glauber's*. See Glauber's Salt.

SALT, *Spirit of*. See Muriatic Acid.

SALTPETRE. See Nitre.

SALT, *Common Salt*, *Muriat of Soda*.—This salt exists abundantly native either as a solid fossil or dissolved in water. In the former case it ranks as a peculiar mineral species, and will be described accordingly.

ROCK SALT, or Fossil Salt, or Sal Gem.—Of this species there are the two following varieties.

Var. 1. Foliated rock salt.

Var. 2. Fibrous rock salt.

Rock salt forms a peculiar species of rock, the proper geological situation of which is between the oldest secondary gypsum and secondary sandstone: it forms continuous beds of great thickness, and often occurs in large solitary blocks: it is always accompanied by semi-indurated clay, for the most part strongly impregnated with salt; and alternates with beds of swinestone, gypsum, limestone, and sandstone. The beds of salt are mostly below the surface of the ground, but sometimes it rises into hills of considerable elevation. At Cordova, in Spain, according to Bowles, there is a hill between four and five hundred feet high, composed entirely of this mineral.

To begin with Europe: there are in *Spain* a considerable number of brine-springs, and some mines of sal gem. Several of these are in lofty situations. Mr. Bowles, who makes this observation, remarks too, that all the salt-springs issue from the foot of some mountain. Such are those of the Pyrenees.

The mine of Cardonna, in Catalonia, near the mountain of Montserrat, is remarkable for this, that the salt forms a homogeneal mass, without any appearance of stratum or crevice, raised about a hundred and eighty yards above the earth, and extending about three miles in circumference. Neither the depth of this heap of salt, nor the nature of the ground on which it rests, is known. The salt composing it is white, or red, or light blue, and is not accompanied with sulphat of lime, which is a rare occurrence.

The mine of Valtierra, in the kingdom of Navarre, near the Ebro, is in a chain of hills at a considerable elevation above the level of the sea. It is enclosed in sulphat of lime.

Beside these, the mine of Servato, in the Pyrenees, is mentioned; and the spring of Salinas, between Vittoria and Mondragon, in the most elevated part of Guipuscoa.

In La Mancha, at Almengranilla, there is a mass of salt similar to that of Cardonna. It is seventy yards in diameter, mixed with sulphat of lime, and covered with the same stone, including crystals of red quartz; above which are siliceous puddingstones, and a stratum of carbonat of lime.

The mines of sal gem, that are wrought at Poza, near Burgos, in Castille, have a remarkable situation, being placed in a vast crater. Mr. Fernandez has found pumice-stones, puzzolana, and other volcanic productions there.

Sal gem is likewise found near Aranjuez and Ocanna, in the transition hills between Sierra-Morena and Madrid.

No mine of sal gem has hitherto been found in *France*, but there are a tolerable number of brine-springs, of which we shall mention those of

Sallies, at the foot of the Pyrenees, near Orther, in the department of the Lower Pyrenees. The soil is calcareous. Sulphat of lime is found in the neighbourhood of the spring.

Salies, to the south of Toulouse, in the department of the Upper Garonne.

Salins and Montmorot, in the department of the Jura. In the first of these two the water contains about 0.15 of salt.

Dieuze, Moyenvoe, and Château-Salins, in the department of the Meurthe. These contain upon an average about 0.13 of salt. These springs, of which there are about twenty, are at no great distance from one another: the first are at the foot of the chain of Jura, the second at the foot of the Vosges. The product of these brine-springs supplies Switzerland with salt.

Montiers, in the department of Mont-Blanc, and consequently in the midst of the higher Alps.

In the same department, near St. Maurice, is the salt rock of Arbonne, which is at a considerable elevation, being near the region of perpetual snow. This is a gypseous stone impregnated with muriat of soda: the salt is extracted by solution in water, and the insoluble matter remains porous and light.

Near Lampertsloch, in the department of the Lower Rhine, are the salt-springs of Sultz; and in the department of the Rhine and Moselle are those of Kreutznach.

Besides these, other brine-springs are mentioned, of which no use has been made, in the department of Côte d'Or; a small salt-lake near Courthezon, in the department of Vaucluse; and several brine-springs, which are now neglected, in the department of the Lower Alps, between Castellane and Tallard. There are some also in the department of the Yonne, at Andreaux and at Camarade; in the department of the Arriège; and in other places.

The only mines of rock-salt in *England* are those in the neighbourhood of Northwich in Cheshire. These were discovered 1670. The first stratum of salt occurs at the depth of about forty yards. The strata vary in thickness, are of a wavy structure, and alternate with strata of clay, under which they are found. The salt is in some places red, in others transparent. The ground over them consists of strata of red-clay, coarse-grained sandstone, blue clay, sulphat of lime, and indurated clay. These mines are the most productive of any in the world. The salt is worked by running galleries into the strata, and leaving pillars of it to support the roof, symetrically arranged, which gives the whole a beautiful appearance. It appears to be free from sulphat of lime.

The brine-springs were known long before the rock-salt was found. When the miners, in searching for them, bore through the stratum of clay that lies over them, they spring up with great force

Germany abounds in salt, particularly in the dissolved state, or brine-springs. These occur almost every where, from Westphalia and the shores of the Baltic, through Pomerania, into Swabia and Austria. About sixty are mentioned, which supply the general consumption throughout Germany. Of these the following are the chief, proceeding from north to south, and from west to east.

In Westphalia, the brine-springs of Rehme, not far from the Ems. These are situate in a plain. Their water is concentrated by graduation.

In the circle of Lower Saxony, the springs of Lunenburg, in the city of the same name, in the electorate of Hanover. These waters do not require to be concentrated by graduation, and they afford no sulphat of lime; which is the more surprising, because there are hills of sulphat of lime near the springs.

Near Brunswick is the salt-spring of Saltzdalen. The spring is at the depth of seventy yards.

Among the brine-springs in the duchy of Magdeburg, those of Halle are to be remarked. Their waters are sufficiently rich in salt, not to require the process of graduation to concentrate them.

In Upper Saxony, in the county of Mansfeldt, are the brine-springs of Artern, six leagues from Eisleben. These afford about two thousand tuns a year.

A great deal of sulphat of lime is deposited by them.

In Prussian Pomerania is that of Colberg; and in Swedish Pomerania, that of Greifswald, on the shores of the Baltic sea.

In the circle of the Upper Rhine, in Hesse, are the brine-springs of Allendorff, on the Werra.

In Franconia, toward the northern part of the circle, are those of Kissingen and Scmalkalde.

It is to be observed, that many of these brine-springs are included within a circle of about a hundred miles, of which the city of Hanover is the centre. In the plains at the foot of the mountains of the Hartz and Thuringerwald, no mines of rock-salt have been found.

We must now proceed to the south of Germany, leaving the mountains of Bohemia, with the circles of Upper Saxony and the Upper Rhine, to the north, before we meet with any more salt In fact, there are salt-mines or brine-springs in Swabia, Bavaria, the Tyrolese, the electorate of Saltzburg, and Upper Austria.

The mines of Tyrol are situated in a very high mountain, two leagues from the city of Halle, on the river Inn, near Innspruck. The sal gem there forms an irregular mass, including fragments of the schist, the *wacke* of Werner, which forms the base of the mountain.

The salt here is wrought in a peculiar manner. Parallel galleries are run into the mass; in these galleries dikes are formed, and water is let into them, where it remains from five to twelve months. When the water is saturated, it is drawn off by pipes, and the solution is evaporated.

In the circle of Austria, the salt mine of Hallein, on the Salza, in the electorate of Saltzburg, is one of the richest in Germany. The mountain that includes it, is composed of saline schists, which are wrought like those of Halle in the Tyrolese just mentioned; but the water is suffered to stand on the salt only two or three weeks. No pillar is left in the vast cavern formed by the galleries, that have been cut into it successively.

The salt-mine of Berchtesgaden, near the former two, is wrought in a similar manner, but it contains more sal gem in mass.

At Reichenhall there are thirty-four brine-springs, containing from one part and an half to thirty parts of salt in a hundred of water, from all of which salt is extracted.

Salt is found likewise at Aussee, in the western part of Styria; and near it, and in Upper Austria, at Gmuenden, Hallstadt, and Ischel.

In *Switzerland* the brine-springs of Bex, in the canton of Berne, are celebrated for the beauty of the subterranean works, that have been executed in search of these deep sources, and to bring them to the surface. The soil in which they are found is a schistous marl, containing some slender veins of sal gem. It appears to include large blocks of carbonat of lime, and to be itself enchased as it were in beds of sulphat of lime rendered impure by a brown clay. The surrounding soil is covered with the same sulphat of lime as occurs in the subterranean excavations. Sulphur has been found in the carbonat of lime. These brine-springs require graduation.

In *Italy* brine-springs are mentioned near Naples; and in Farther Calabria, near Altamonte, at the foot of the Apennines. These springs contain sulphat of lime also.

In the middle of the Island of Sicily, and toward the western part, there are brine-springs, near Castro Giovani, Calatascibetta, Regalmuto, Cattolica, and other places.

It appears from the preceding account, that the majority of brine-springs and mines of rock-salt are found at the foot of high mountainous chains. The mines of Transylvania, Upper Hungary, Moldavia, and Poland, are further proofs of this general principle. These mines, which are very numerous, and important with regard to their extent, the vast bodies of salt they contain, and their product, are found along the chain of the Carpathian mountains, and spread nearly in an equal degree on each side of the chain. They accompany these mountains to the extent of more than two hundred leagues, from Wieliczka in Poland, toward the north, to Fokszian, or Rymnick, in Moldavia, to the south.

The strip of land that contains the salt-mines or brine-springs is near forty leagues broad in some parts. In it may be reckoned about sixteen mines, that are worked for salt; forty-three indications of mines, that have never been wrought; and four hundred and twenty or four hundred and thirty brine-springs.

The most remarkable of these are, beginning in the north-east and proceeding in a southerly direction, those of Wieliczka, Bochnia, and Samber, in Poland; and some brine-springs in Buchovina and Moldavia, particularly near Ockna. On the south-west of the chain, following the same direction, are those of Sowar, near Eperies, in Upper Hungary; of Marma-

rosch, in Hungary; of Dees, Torda, Paraïd, and Visackna, near Hermanstadt, in Transylvania; &c.

The salt-mines of Wieliczka, near Cracow, and those of Bochnia, which appear to be a branch of them, are celebrated from the accounts given of them, by almost every traveller in that country, many of whom have represented them, in too strong colours. They are very ancient, having been worked ever since the year 1251. In other respects, they have nothing to distinguish them above others, except the extent of the works in the beds of rock-salt, the dimensions of which still remain unknown. The ground that covers them, is composed, like that over most other salt-mines, of alternate strata of sand, marl, pebbles, and marl including large blocks of salt. Such of these blocks as are first found, are mingled with clay, and called *green salt*. The purest salt is called *schibika*. These mines are about two hundred and eighty yards deep.

In the mine of Bochina, the salt presents itself in a stratum at once, and not in detached pieces. The strata of clay, as well as those of salt, are undulated, and not of a uniform thickness. The salt is sometimes brown, at others reddish, and at others transparent. The different coloured salt, is not arranged in parallel layers. The strata dip at an angle of about forty degrees, with the horizon. Townson informs us, that very beautiful specimens of fibrous muriat of soda are found in it.

At Thorda, the mass cf salt is divided into horizontal, but undulated strata.—These strata are two or three centimetres, (near eight or twelve inches) thick. The lowest are the most undulated.

You go down into the salt-mines of Wieliczka, by six shafts of four or five yards, in diameter. Various structures have been formed, in the body cf the salt itself. We find there a stable, chambers, and chapels, all the parts of which, as pillars, altars, and statues, are of salt. The shafts and galleries, are perfectly dry, so that you are more incommoded, with dust than dirt. There are springs, however, both af salt water, and of fresh, in these mines. It appears, that the air is not so foul in them, as in most salt mines: but the workmen do not reside in them, as some have asserted. In certain parts of the mine, hydrogen gas sometimes collects, and takes fire.

The salt is cut out, in little ascending steps. It is formed into parallelopipedons, weighing about 80 or a 100 lbs. or into cylinders, which are put into casks. This mine produces about six thousand tons of salt every year.

Near Ockna, in Moldavia, there is a hill of rock-salt, in many parts of which, the salt appears exposed to view.

The mines on the south-east of the Carpathian chain, appear more numerous, and are dispersed through a greater space of ground, than those of the north-east. They are in general very near the surface. Some of those in Transylvania, are so to such a degree, that persons are appointed, to cover the salt with turf, when it is washed bare by the rain. These masses, however, are so thick, that their bottom has never been found. If they be not worked to the depth, of a hundred and seventy or eighty yards, it is because the extraction of the salt, becomes too expensive. In the county of Marmaroch, they have been wrought to the depth of upwards of two hundred yards. These mines contain likewise a great deal of petroleum; and the ground in which they are contained, is every where furrowed by rivers. The mud interposed, between the water of these, and the salts, is imagined to prevent the salt, from being dissolved by them.

At Paraid, in Transylvania, there is a valley, the bottom and sides of which are of pure salt. Walls of salt appear there 60 or 70 yards high.

The mine of Eperies, is three hundred and sixty yards deep.

In the salt-mines of Marmarosch, water has been found included in the substance of the salt rock.

The mines on the south-west of the Carpathian mountains, are generally wrought by means of shafts. There are at least two to each mine; one for the workmen, the other for drawing up the salt. The salt is cut out in ascending steps, which produces empty spaces of a conical form, in the midst of the strata. The ladders reach perpendicularly to the bottom of this conical space, so that within it, they stand perfectly detached. Thus the greater part of the body of salt is extracted, leaving empty spaces, which are conical, and which communicate with one another, by means of galleries. It has been thought, that, in order to leave less salt, it would be better to give these spaces the shape of a parabola, or rather even a square, with vertical walls meeting together, in the form of an ogee. The salt is so plentiful, that the miners are paid only for such pieces, as weigh upward of eighty pounds; the others being rejected as useless. When the workmen

are incommoded by water, it is drawn up in leathern bags, to be emptied out of the mine.

The Transylvanians and Moldavians, extract salt from their brine-springs, by throwing the water on wood fires, as the Gauls and Germans did, in former days.

No salt-mine or brine-spring is known either in Sweden or in Norway.

There are a great number of both, and particularly of salt lakes, in Russia. The latter is peculiar to that country, there being no salt lakes in any other part of Europe.

Among these is the salt lake of Tor, toward the northern extremity of Little Tatary.

There are similar salt lakes in the Crimea, which appear to belong to the same system.

At Balachna, on the banks of the Wolga, are some very rich brine-springs.

We now proceed to Asia.

In Russia in Asia, we find the brine-springs of Permia, of which there are a great number, at the foot of the mountains of Poyas.

About 80 wersts from Yena Tayeoska, in the desert, between the Wolga and the Ouralian mountains, there is a mine of rock-salt.

In the government of Astracan, to the north of the Caspian sea, in the environs of Orenburg, and in the country of the Bashkirians, salt lakes are very common; and the water evaporating during the summer, the salt appears chrystallized on their surface, and round their borders. When this water is highly concentrated, it has a deep red colour. The salt formed in them, has often the same hue; and when this is the case, it diffuses a very perceptible violet smell.

One of these is the salt lake of Elton, above Astracan, in the re-entering angle formed by the Wolga. The Kalmucks call it the Golden Lake, because of its red appearance, when the sun shines on it.

The lake of Bogdo, situate near this, yields a perfectly white salt, free from sulphat of magnesia, and preferred to that of lake Elton.

Near Astracan too, is the mine of Iletzki, celebrated for the quantity of salt it furnishes. The salt lies at no great depth, and rests on a very hard clay. The soil above it is sandy, and full of holes, containing water saturated with salt.

In Siberia, there is a mine of rock-salt, on the right bank of the Kaptendoi; and on that of the Kawda, are fourteen brine-springs. Others are found in the government of Kolivan, and in the environs of Irkutsk, near the lake Baikal, in the centre of Asiatic Russia. Lastly, the country near the Caspian sea, is so impregnated with muriat of soda, that in the environs of Gourief, the fogs and dew, that settle on people's clothes and on plants, are saline.

Among the Mungal Tatars, the soil is so thoroughly penetrated with muriat of soda, that the people lixiviate it, and evaporate the solution, to obtain the salt.

That part of China, which borders on Tatary contains salt mines, and the ground is strongly impregnated with salt.

Salt is found in the same manner, throughout almost the whole table-land of Great Tatary, Tibet, Indostan, and particularly Persia, where very extensive plains are seen, covered with saline efflorescenses. This is eminently the case near Bender-Congo.

The isle of Ormus, at the mouth of the Persian Gulf, appears to be one large rock of salt.

This substance is likewise found, in solid masses near Balach, on the eastern frontier of Persia; in the environs of Ispahan, in Media; in the mountains that surround Komm, to the north of Ispahan; &c.

In California, salt is found in a very pure state, and in large solid masses.

The mountain of Xaragua, in the island of St. Domingo, affords salt; and in the same island there is a very remarkable salt lake, about twenty-two leagues in circumference, called Henriquelle. The water, which is inhabitted by lizards, alligators, and land tortoises, all of a large size, is deep, clear, bitter, salt, and of a disagreeable smell. Near the middle of the lake is an island, about six miles long and three broad, well stocked with goats, whence it has the name of Cabrito Island; and in this island, is a spring of fresh water.

Salt lakes occur in others of the West India islands.

In Peru, there are several mines of sal gem, in very hard masses. What is remarkable in their position, is, that they are in the highest part of the country, as for instance in Potosi. The most usual colour of the salt, is a jasper violet.

There are likewise salt plains, in South America. One of great extent is mentioned, in the environs of Lepis, towards the northern extremity of Peru. Another in Chili, in the provinces of Copiapo and Coquimbo, which are nearest to Peru. And, lastly, in the southern extremity of America, near St. Julian's Bay, in Patagonia, there is a salt marsh two miles long.

These are the principal places in the

globe, where salt is found. It occurs likewise, but in less quantity, in springs of mineral water, holding other saline substances in solutiou, such as those of Balaruc, Bourbon, Bourbon-Lancy, Lamotte, &c.

Though salt is generally used in small quantities, its use is so general and constant, that a vast quantity is consumed merely for seasoning our food. A still more considerable quantity is employed, in salting various kinds of provision, chiefly animal, but some vegetable, to preserve it for use. Considered in this light, it is of great importance, affording employment to a number of persons, and furnishing several articles of commerce. Hence it was natural, that endeavours should be made to extract it as cheaply as possible, in every place where nature offers it to us, with bountiful profusion.

The salt springs of Onondago and Cayuga, in the state of New-York, furnish about 300,000 bushels a year; and the quantity may be increased, in proportion to the demand. Those of the western states and territories, supply about an equal quantity; that known by the name of the Wabash Saline, which belongs to the United States, making now 130,000 bushels. Valuable discoveries have also lately been made on the banks of the Kenhawa. But the annual importation of foreign salt amounts to more than three millions of bushels, and cannot be superseded by American salt, unless it be made along the sea coast. The works in the state of Massachusetts are declining, and cannot proceed, unless the duty on foreign salt should again be laid. It is necessary to shelter the works from the heavy summer rains by light roofs moving on rollers. This considerably increases the expense; and it appears that the erection of ten thousand superficial square feet, costs one thousand dollars, and that they produce only two hundred bushels a year. A more favourable result is anticipated on the coast of North Carolina, on account of the difference in the climate, and works covering 275,000 square feet have been lately erected there.

Salt has also been obtained by the evaporation of sea water, after several of the European methods.

Muriat of soda has a pure saline taste without any mixture of bitterness. It crystallizes in cubes when obtained by slow evaporation from its solution, but when procured by a boiling heat (as is the case with most of the salt used for culinary purposes) the form is that of a hollow inverted pyramid, resembling a hopper, and is made by a successive aggregation of cubes round a central one, whilst floating on the surface of the brine, whilst the increasing bulk of the mass causes it gradually to sink lower in the liquor.

Common salt is very soluble in water; 8 parts of the latter will dissolve somewhat less than 3 of salt at a moderate temperature, and scarcely any more is taken up at a boiling heat; so that no salt can be obtained from a hot saturated solution by mere cooling, but only by evaporation of the fluid. Salt contains but little water of crystallization, and hence when thrown in the fire, or suddenly heated, it decrepitates or flies to pieces with a crackling noise. If heated red hot it melts, and at a still higher temperature it flies off in the form of dense white fumes, but is not decomposed by volatilization.

It is composed, according to Kirwan, of 53 per cent of soda, and 47 muriatic acid and water, and the quantity of real acid is such that 100 parts of the crystallized salt decomposed by nitrat of silver, will give 233½ of luna cornea, of which the mere acid is 38.6. It must be observed, that there is some difference in the analyses of different chemists, but taking the above data as correct, 100 parts of crystallized muriat of soda will contain 53 of soda, 38.6 of acid, and 8.4 of water.

Muriat of soda may be decomposed in a variety of ways: its acid is readily and totally expelled by the sulphuric at a moderate heat: its alkali may be procured by a variety of methods, many of which are used in the great way, and will be shortly described at the end of this article.

We now proceed to the mention of methods by which are procured the immense quantities of common salt employed by man in almost every country on the face of the globe.

It has been already mentioned that native salt is found, either solid, under the surface of the earth, or dissolved in natural brine springs, which are always found in the neighbourhood of rock salt: or it is left by the spontaneous evaporation of many inland lakes and pools in different parts of the world: or lastly, an inexhaustible store of it is contained in the waters of the ocean. Sometimes the rock salt is found sufficiently pure to be used without any preparation; this, however, is rare, for by far the greater part of the salt used throughout the globe, is got by evaporation of salt water, either by natural or artificial heat, or often by both. The general process of making salt from brine by artificial heat, is very simple and obvious,

being little else than putting the brine into a broad shallow iron pan, bringing it to a boiling heat by furnaces underneath, and continuing the evaporation nearly to dryness, during which the salt gradually separates as the water is dissipated, and is afterwards collected and gently dried. But there are several circumstances relating to salt-making which deserve the attention of the chemist, and require to be related more at large.

We shall give in a few words the process of salt making as practised in Cheshire, England, being the place whence most of the salt used in that country is obtained.

The brine is first pumped up from very deep wells, by powerful machinery, and is discharged in a large pond or reservoir. If the brine is weak in salt, it is generally strengthened and nearly saturated by throwing in a quantity of the more impure rock salt dug up in the neighbourhood, particularly in those salt-works that have the convenience of water-carriage from the pits. There is a considerable difference in the purity of the brine from different pits: all contain a small portion of earthy salt, chiefly sulphat of lime, and a small quantity of carbonat of lime held in solution by an excess of carbonic acid, and frequently also a little carbonat of iron. The purest brine is perfectly limpid, of a pure saline taste, and a peculiar cold green hue. This last indicates the absence of iron, for when even the smallest admixture of oxyd of iron is present, the water has a yellowish cast, and the salt made from it never acquires that delicate blue whiteness, which is considered as a criterion of its perfection. The salt-pans where the brine is boiled down, are oblong shallow troughs of wrought iron, usually from 20 to 30 feet long and broad, and about 9 to 12 inches deep. They are set strongly upon masonry, over a large furnace, the flues of which draw all round the pan. The fuel is coal, of which there are many pits at no great distance. Each pan stands in a small covered building, with a pyramidal roof, formed of boards, sloping downwards, but with a considerable interval between each, so as to keep off the rain, and at the same time to allow of a free passage for the steam of the boiling brine.

The whole process of boiling, purifying, and evaporating the brine, is performed in this single pan.

The brine, after standing some days in the reservoir, is pumped into the pan. When heated to about 100° it begins to grow turbid, owing to the deposition of the carbonat of lime and of iron (if any) by the expulsion of the carbonic acid which held them in solution. This forms a scum on the surface of the brine which is partly removed by a skimming dish, but much of it falls to the bottom, and if suffered to remain, would materially injure the quality of the salt. To clear it out, the brine is evaporated till it begins to *salt*, that is, till a portion of the muriat of soda begins to separate, and this falling to the bottom, mixes with the carbonat of lime, and gives it a body, which enables the workman to draw it out. This is carefully done, and the sediment thus obtained (called *clearings*) is thrown away, which from a pan of 24 feet by 27, usually amounts to about three or four bushels. The evaporation is then continued at a boiling heat, and the salt gradually collects at the surface and falls to the bottom in beautiful crystals of a pure and delicate white, where the brine is good. As the process advances and the salt collects in quantity, it is fished out from the bottom of the pans by wooden vessels, and poured into large hollow wooden cones, with a hole at bottom, and suspended round the side of the pans. Here it drains, and the drainings drop again into the pans. When the process is completed, and the contents of the pan evaporated almost to dryness (which usually takes a single day and a night) the cones full of the salt are taken to a large room made very hot by stoves, where they remain till thoroughly dry.

The grain of the salt is determined by the rapidity of the evaporation and the degree of heat used. In the common salt-making the water is evaporated at a full boiling heat, that is, as fast as possible, and hence the grain is small, and the salt comparatively soft. The contents of a single pan are usually worked off in twenty-four hours, except from Saturday to Monday, when two days are taken, and hence a larger and harder grained salt is made, which is much esteemed in the country for salting cheese.

It is found by experience, that some brines will not readily salt by mere evaporation, but that some addition is required to make them work well, and the salt fall regularly. This addition is generally calves' feet jelly, sometimes glue, sometimes white of eggs, sometimes blood, and, in short, any animal or vegetable mucilage seems to answer the purpose. It is usual to have standing in a corner of the pan an earthen vessel, containing eight or ten pair of calves' feet, to which hot brine is added to extract the jelly: and after the *clearings* are removed and the brine begins to salt, the workman

adds a little of the jelly at discretion. The precise use of this addition is by no means obvious, nor is it absolutely necessary, but long experience has shewn it to be useful in many kinds of brine.

Another difficulty sometimes arises. In general the brine, when it has once begun to *salt*, goes on to work well to the last, every part of the surface being sufficiently covered with small crystals of salt, which soon grow into a group, forming a small floating island of salt, which soon sinks to the bottom by its own weight, and leaves a clear surface above, which again is covered in the same manner. But sometimes from some unknown cause, a thick shapeless crust of salt forms rapidly over the whole pan, which soon hardens to a dry floating cake of salt, preventing, in a great measure, the escape of the steam, and materially retarding the process. To remedy this, a small lump of butter, not more than about half an ounce, is thrown into the pan, which quickly melts and diffuses itself over the dry cake of salt, and causes it to break up and sink, after which the salting goes on well.

After the brine has been evaporated nearly to dryness, and indeed during the latter part of the boiling, there is deposited on the bottom and sides of the pan, a hard, white, saline and earthy crust, which strongly adheres to the pan, and is partly fused to its surface by the intensity of the fire, in proportion as the sides become dry by the loss of liquid.

This crust daily accumulates, and produces much inconvenience, partly by injuring the quality of the salt, but chiefly by increasing the distance between the fire and the brine, and forming a thick coating through which the heat penetrates with difficulty. Hence it becomes necessary about once a month to discontinue the boiling for a day, and to pick and beat off this crust with hammer and chissel, often to the great injury of the pan itself. The *pickings*, or *pan-scratch*, as they are also called, are thrown away. Their analysis will be mentioned afterwards.

A very large-grained and beautiful salt is made at Liverpool, and some other places, by very slow evaporation of saturated brine, and strings or sticks are put into the pan, on which the crystals form, as in the making of sugar-candy. This salt is used in the curing of fish, and is called fishery-salt.

The chemical analysis of the different brines, and products or impurities in salt-making, will be presently mentioned.

As the greatest inconvenience in salt-making is the precipitation of the earthy impurities, and the difficulty of preventing them from mixing with the salt, a plan has lately been adopted (under patent) in some works, of heating the brine in a separate pan to the degree at which the earthy carbonats precipitate, before it is sent into the large salting pan. It is found, that the same fire, by extending the flues, will heat this preparing pan, which is contiguous to the other, and the time in which one pan-full is worked off, is sufficient to bring the fresh portion to the requisite heat, and to purify it considerably.

When a weak brine is exposed to the atmosphere, the watery part gradually evaporates, and with it the carbonic acid which it contains, the effect of which is to concentrate the solution and also to cause the deposition of the earth and oxyd of iron, which the carbonic acid held dissolved. As evaporation much depends on the surface exposed to the air, a very ingenious method has been adopted of promoting this, by causing the weak brine to fall successively through large bundles of faggots, whereby a vast consumption of time and fuel in the subsequent evaporation is prevented. This operation is called *graduation*, and the place in which it is performed a *graduating house.*

This consists of a very long range of rows of faggots placed perpendicularly, and rising to the height of about 25 feet, and disposed in cones, the summits of which are about 6 feet in diameter, and the bases about 10. Just above the faggots is a trough perforated with holes at small intervals, furnished with stop-cocks, and the whole is covered with a penthouse roof. At the bottom of the faggots is another trough to catch the brine. The length of these houses is determined by the quantity of brine wanted, sometimes it is enormous. In some parts of Germany there are graduating houses six thousand feet long; but, in general, they are from 200 to 1000, as will be more fully noticed.

The weak brine is first raised by pumps to the upper trough, when the stop-cocks are turned, and the water made to fall like a shower of rain through the faggots into the trough below. It is then again forced up, and undergoes the same operation successively till it is sufficiently concentrated. The state of the atmosphere has the greatest influence on the graduation of the brine. The evaporation goes on the quickest in a dry air with a moderate wind: when the wind is violent, much of the brine is carried away in the state of spray or vapour, particularly

when the column of faggots is not pyramidal, but has the same dimensions throughout. As a proof of this waste, Haller observes that in the neighbourhood of these graduating houses the ground becomes in a few years covered with the salicornia and other plants which are known to require a salt soil and flourish on the sea-shore.

It has been mentioned, that in proportion as the brine becomes concentrated it parts with its carbonic acid, and deposits carbonat of lime, and hence the faggots of the graduating houses become gradually encrusted, over every twig, with a brown, hard, earthy matter, consisting chiefly of carbonat of lime. Thus, in a course of years, the faggots are entirely covered with stalactite as in the common petrifactions, and the surfaces for evaporation become thereby so much diminished, that it is necessary to replace them with fresh faggots. The time that one set of faggots will last, is about eight or ten years.

The effect of graduation in concentrating brine is very striking Baron Haller, in his valuable memoir on the subject, gives the result of many observations on this and other particulars relating to the salt-works in Switzerland, of which he was the director.

The brine springs in that country seldom contain more than one per cent. of salt in the natural state, but by mere graduation the brine is brought as high as 20 per cent after which it is ready to be boiled down as usual. To effect this concentration therefore, 20 parts of brine must part with 19 by evaporation through the faggots. The deposition of stalactite hardly begins till the brine is brought to 5 per cent. of salt, and it ceases altogether when it is brought to 15 per cent The graduation of the brine becomes slower as the concentration increases. With regard to the actual effect of a given quantity of faggots, Haller finds that at a mean degree of concentration, or 10 per cent., the evaporation of a single day in Switzerland, taking the average of the entire year, is 1100 cubic feet, (reckoning the weight of the cubic foot at 46 lbs of 18 oz.) in a row of faggots 20 feet high, and 735 long. When the sun shines strongly, the exhalation is more than double the above quantity.

A graduating house of the above dimensions is estimated to have always at work about 1,912,000 lbs. of brine, and this quantity is furnished eleven times in the year to the boiling pans. There appear to be two inconveniences in graduation; one, which is but trifling, is, that the brine extracts at first some colouring matter from the faggots, which is never totally got rid of in the subsequent evaporation, so that the salt has a little brownish tinge. The other is more serious, and it is the actual loss of brine by graduation, either when the wind is too violent, or the process managed unskilfully and the faggots not well arranged. This, in some salt-works, is estimated as high as from 30 to 40 per cent.

Klaproth has some valuable experiments on graduated brines, in his analysis of the salt springs of Konigsborn, which is a salt mountain extending from Paderborn to the duchy of Cleves, and into the bishopric of Munster. The brine is found much stronger the deeper it is drawn. That obtained at 50 feet from the surface contains only 1 1-4 to 2 per cent. of salt; at 80 feet it is 2 3-4; and at 120 feet it rises to 3 1-4 or 3 1-2 per cent.

The method pursued by this excellent chemist in the analysis of the brine, may be also shortly mentioned as a direction to the reader who may wish to repeat the experiments.

1. Fifty cubic inches of brine (each equal to 290 grs. of distilled water) were evaporated to dryness in a sand heat, and the weight noted.

2. The residue was covered with alcohol, and digested in a moderate heat for 24 hours.

3. The alcoholic solution was poured off and evaporated to dryness, and fresh alcohol poured on the residue in order to redissolve all the salts, except the small portion of common salt which the first alcohol had taken up. The last alcoholic solution was then evaporated to dryness and the residue weighed.

4. The dry residue from the last alcoholic solution consisted of muriat of lime, and muriat of magnesia; and the weight of each was determined in the following manner: the residue was dissolved in water, and the earth precipitated by carbonat of soda. This earth, well washed, was then combined with sulphuric acid to excess, and after the mixture had stood a while in a warm place, the excess of acid was absorbed by adding carbonat of lime. The solution was then evaporated considerably (removing the sulphat of lime as it was formed) and then exposed to exhalation in the open air, whereby the sulphat of magnesia was separated in crystals. These last were collected, redissolved in water, decomposed by soda, and the magnesia saturated with muriatic acid and evaporated to dryness. It was then pure muriat of magnesia, brought to the state in which it existed in the dry residue

of the brine, and the weight of the muriated lime, originally mixed with it was found by subtracting the weight of the muriat of the magnesia, from that of the entire alcoholic residue.

5. The dry salt remaining after the separation of these earthy muriats, was then dissolved in water, and filtered.

6. What was left on the filter, consisted of sulphat and carbonat of lime, and oxyd of iron. When weighed, it was treated with muriatic acid, and the sulphat of lime left on the filter. Ammonia was added to separate the iron, which was collected and weighed.

7. The clear solution of No. 5, might still contain sulphat of lime; it was therefore boiled with carbonated soda, when a carbonated lime fell down. The soda added, was then neutralized by muriatic acid, and muriat of barytes added, which gave a precipitate of sulphat of barytes, shewing therefore the existence of sulphuric acid in the brine, which must have been combined with the lime, obtained by the soda. The quantity of sulphat of lime, was inferred from the united weights of the carbonat of lime, and the sulphat of barytes, and from the quantity of the latter also, it was proved that no other sulphat existed, than that of lime. The same was also shewn, by the gradual solution of the salt, in a mixture of two parts of alcohol, and one of water, for the sulphats will not sensibly dissolve in this mixture without heat.

When the brine is boiled down, what remains of the carbonat of lime, in it, is precipitated along with selenite and common salt, and forms that hard crust, which adheres so firmly to the pan, and has been described already under the term, *pickings* or *pan-scratch.*

The mother water, or liquor left in the salt pan, after all the salt that it is thought proper to work off, is taken out, is a very dense bitter fluid. Its specific gravity, is as high as 1.218. Fifty cubic inches yielded by evaporation, 5440 grains of dry salt, composed of

Muriated lime	660
——— Magnesia . .	840
Sulphat of lime	100
Common salt.	3840
	5440

It is remarkale that the muriated magnesia, is here a fourth more than the muriated lime, whereas in the brine, both rough and graduated, it is not more than one-thirtieth or one-fortieth of the muriated lime. Hence much of the latter, must be decomposed during the boiling, to which Klaproth attributes the strong smell of muriatic acid, perceivable when the evaporation is nearly completed.

A very full and accurate account of all the processes employed in the large salt-works of Salins, Moyenvic, and other brine springs in Franche Comte, in the South of France, on the borders of Savoy, is given by Nicolas, who examined them on the spot.

We shall not transcribe it at large to avoid repetition, the general method being that already mentioned, viz. of concentrating the brine by graduation, then boiling down in iron pans. By some varieties of practice, and other circumstances contained in this valuable memoir, are worth relating.

The brine gives by analyses, the following ingredients. One French pound (of 16 oz. and 576 grs. to the ounce) contains of

	oz.	grs.
Muriat of soda	7 —	529
Sulphat of lime		23
Sulphat of soda		75
Muriat of lime and magnesia		81

Three kinds of salt are made at Salins, namely, large grained, small grained, and loaf-salt. The common or small grained, is that which is made at a boiling heat, continued to the last. The large grained is made in small pans, placed contiguous to the boiling pans, and supplied by the same fire, the flues being continued under them. The heat in these, is but slow, and the evaporation moderate, which allows the salt to form in large crystals. The earthy-saline scum, which forms during the boiling, is afterwards lixiviated, to extract the salt which it contains. The *schlot* or *pickings* from the pans, contains much Glauber's salt, which is also extracted by hot water, and when the solution is so far concentrated, that it would crystallize by cooling, it is stirred constantly till cold, which makes the salt assume a needled form, like the common Epsom salt, and it is sold as such.

A very ingenious plan has been introduced here, of applying the principle of evaporation by the atmosphere, not only to the concentration of the brine, but to the actual crystallization of the salt which it contains. For this purpose, the brine after common graduation on faggots, is heated in the pan till it begins to salt. It is then conveyed to another graduating house about 250 feet long, divided by party walls into six arches. These support troughs, extending the whole length

of the building, and furnished with proper holes for the brine to fall down. The space under each arch, is filled with 40 rows of endless cords, stretched vertically on wooden frames, each of which contains 25 double cords, parallel to each other, and about three inches asunder. The whole building contains 6000 of these double cords, about three or four lines in diameter, and about 30 feet long. The flooring of the building is made of fir planks, well put together, and gently sloping to one end, to convey the brine as it falls, into a large reservoir, from which it is again pumped up to the upper trough. The side of the building most exposed to the weather, is protected by a canvas. The hot brine as it passes from the boiler, is sent to the upper trough, and then falls down every one of the cords in a copious stream, round which the salt gradually crystallizes in a stalactical form. When the crust of salt forms a cylinder from two, to two and an half inches in diameter, it is taken off, and the process repeated. Each operation produces from 3500 to 4000 quintals of excellent salt, and requires about a month to be formed; and as this work can only be carried on in the height of summer, the cords can be charged no more than twice, or at the utmost thrice in the year.

The salt is broken by a kind of moveable flail set in a frame, in which each row of cords is placed in turn.

The country of Saltzbourg, on the borders of the Tyrol, furnishes a vast supply of salt, which is procured from a large salt mountain, near the town of Hallein. No brine springs are found here, which is a remarkable circumstance, as in general the neighbourhood of rock salt abounds in water. The rock salt however, is not worked out in mass in this country, but an artificial brine is made in the following manner.

A horizontal gallery is cut into the mountain, through the middle of the rock salt, from 50 to 200 fathoms in length, five feet high, and four wide. This gallery is supported above, and on the sides by planking, and the opening is shut up by an earthen wall. Fresh water is then let in from springs, collected on the upper part of the mountain, till the whole gallery is filled. In two or three weeks, the water by resting on the salt, has acquired 22 per cent. of saltness, after which it is drawn off and boiled down as usual. This process is then repeated as often as necessary, till by degrees, the galleries by the gradual solution of the sides and floor, enlarge into vast caverns. The roof never enlarges, which is rather a singular circumstance.

The sea is an inexhaustible source of salt, and vast quantities of it are made from sea-water, in different countries. Sea-water is but a weak brine, the solid contents of which, vary in different parts of the world. In the Baltic, it is not more than one-fortieth, in the British Channel about one-thirtieth, and taken at a great depth near the Equator, it is about one-twenty-third, in which state, its specific gravity is 1.0289, according to Bergman, who has analized it. By the experiments of this excellent chemist, it appears that an English wine pint of this sea-water, (of 28.875 cubic inches) contained,

	grains.
Of Muriated soda . .	241
Of Muriated magnesia .	65.5
Of Sulphat of lime . .	8.
	314.5

A small portion of carbonated magnesia, also separates during the evaporation.

Sea-water therefore contains a very large proportion of other saline matters, besides common salt, more so than the common brine springs, and this being chiefly muriated magnesia, the salt procured from sea-water, is apt to be bitter and subject to deliquescence, unless a good deal of pains be taken in the boiling, or unless the evaporation be conducted very slowly. There are several ways of getting the salt by sea-water: in warm climates, this is done altogether by the heat of the atmosphere, and this forms the large grained strong dry salt, called bay salt, which is preferred to any other for curing provisions, that are intended to keep for any length of time. Bay salt is made in great perfection in Spain and Portugal, by the Biscayans, and on the Mediterranean shores of France, and in the Bahama islands in the West Indies. The process is simple, and requires but little apparatus of any kind.

The first requisite is a sea marsh, or shallow artificial pond, near enough to the sea, to be filled at high water. A level shore must therefore be chosen, and the soil must be clayey, to retain the water. The bottom of the pond is then laid out perfectly even, and beaten hard and smooth, and a channel with flood-gates, is cut to the sea. The salt pools consist always of a large reservoir, communicating directly with the sea at one end, and at the other with a number of smaller pits or beds, on which the salt is made

The water is first evaporated by the sun's heat, considerably in the reservoir, and then conveyed to the salt beds, which are only a few inches deep, and in which the evaporation is completed, also by the sun and wind, and the salt separates first in the form of a white crust, which is broken from time to time, to expose a fresh surface to the air. The concentrated brine yields salt about twice, and sometimes thrice a week in summer. The first saline crust that forms, is small grained, the latter large. Bay salt has generally a little tinge of colour, green or brown, according to the soil on which it is formed. It is only made in the summer months.

Another way of making salt from sea-water, and which is practised much on the French, and other coasts of temperate climates ; is partly by the atmospherical evaporation, and partly by boiling, for the summers are not hot enough in this climate to make salt by mere exposure to the air. The general mode of proceeding, is that already mentioned, that is to say, the sea-water is exposed during the summer in shallow artificial pools, where it becomes highly concentrated, and this is afterwards boiled down in iron pans, in the usual mode. This way is adopted largely in Scotland, and in a few parts of England, particularly at Lymington. The mother water that remains after the most of the salt has been extracted, contains much muriat of magnesia, and this is advantageously converted into the sulphat of magnesia, as will be mentioned under that article.

There is still another method of extracting the salt from sea-water, which is by collecting the sand that has been repeatedly moistened by the sea-water and dried, and lixiviating it in reservoirs, where it forms a very strong brine, which is then boiled down as usual. This way is much practised on the western coast of France, particularly in Lower Normandy, and at the isles of Oleron and Rhé.

The spot being chosen (which should be on a level shore with a clean sand) the necessary buildings are erected, namely, evaporating pans, store-houses, covered sheds, &c. and an area of three or four acres is selected a little below the level of the spring tides and above the neap. The surface is carefully levelled by the plough, and rolled smooth and hard. It is then filled to the height of several inches with sand taken from the edge of the sea at low water, and the sand is also drenched with sea-water as the tide flows in. It then lies exposed to the sun and wind, which soon dissipate the superfluous water, and the surface of the sand appears covered with a white efflorescence. It is then turned over frequently with a kind of shovel, changing the surface several times a day till the whole is thoroughly dry. This saline sand is then carried to the sheds, and the process repeated with fresh sand till a large quantity is collected, which generally employs the whole summer. To make the salt, the dry sand is taken out of the sheds, and thrown into small round pits about 2½ feet in diameter, and 12 inches deep, the bottoms of which are lined with hard rammed clay mixed with chopped straw, to prevent the water from oozing through. The sand is then covered with sea-water, or with the weaker ley of former operations, and after standing some hours is drawn off into reservoirs or barrels, whence the evaporating pans are immediately supplied. The sand is lixiviated a second time, and this ley is reserved for a fresh portion of sand. The boilers are of lead, about 3½ feet square, and 4 or 6 inches deep. They are heated with wood of any kind, or sometimes with reeds, and a boiler of this kind is worked off in from two to three hours. The salt is raked out as it forms, and drained in hollow cones, as in other places. Three pans of this dimension yield about 50 lbs. of salt.

The salt procured in this way is white and small grained, but it is very apt to be damp, and is a weak-bodied salt little fit for preserving animal food for any length of time.

In some northern countries some advantage is made of the effect of cold in concentrating brine, by freezing at first only the more watery part, of course leaving the unfrozen part proportionably richer in salt. The winters of this country are not cold enough in general for this purpose, but it is used occasionally on the Baltic coasts. The cold, however, must not be too intense, otherwise the brine itself freezes. Frozen salt water is not in hard solid masses like fresh water, but it is soft and crumbly or rotten. The efficacy of this method of concentrating brine is very considerable.

Though much of the French sea-salt is very indifferent, the Dutch refine it into a very excellent salt, which is used in pickling the herrings for which that nation is so justly famous, and which trade is under the strictest inspection as to the goodness of the salt, and the care to be taken in every step of the business. It is not precisely known whether the Dutch do any thing more than boil the salt again, and evaporate slowly, except that it is the constant custom when the brine begins to

salt, to add a small quantity of very sour whey, which is found by experience to be a very important addition.

We shall now communicate some of the processes more minutely; and add, at the same time, a few plates representing the apparatus and machinery used in the manufacture of salt.

Plate XIV. exhibits a plan of a set of brine-pits.

A, A The great reservoir, into which the water flows through the sluice *a*.

B, B, B. The second reservoir. Into this the water enters by a subterranean channel at *b*, and circulating through the several divisions in the direction of the shaded line, finds its exit at *d*.

c, c, c, c. Narrow banks of earth separating the divisions.

C, C, C. The third reservoir. The water, on quitting the second reservoir, enters through an aperture at *d* the long narrow channel at *d, e, f, g, h*, whence it flows into C, C, C, as it had before done B, B, B.

D, D, D, D. The fourth reservoir, into which the water flows as shown in the plate from the third reservoir; and from which it is ultimately distributed among the small square basins E, E, E, E, E, E, E, E.

i, i, i, i. Heaps of salt drawn out of the basins E, E, and left to drain.

K, K. The salt collected together in larger heaps, and left to drain still more.

The water of the sea is let into these reservoirs in the month of March. It affords, as is apparent, a vast surface for evaporation. The first reservoir is intended to detain the water till its impurities have subsided, while at the same time the evaporation commences in it. From this the other reservoirs are supplied, as their water evaporates. The salt is considered as on the point of crystallizing, when the water begins to grow red. Soon after this a pellicle forms on the surface, which breaks, and falls to the bottom. Sometimes the salt is allowed to subside in the first compartments, sometimes it is made to pass on to others, where a large surface is exposed to the air. In either case the salt is drawn out, and left upon the borders of the pans to drain and dry. In this way it is collected two or three times a week toward the end of the operation.

The salt thus obtained partakes of the colour of the bottom on which it is formed; according to the nature of which it is white, red, or gray. The last is frequently called green salt. Sea-salt has the inconvenience of tasting bitter, if used immediately after it is made. This is owing to the muriat of lime and sulphat of soda, with which it is contaminated. By exposure to the air for two or three years it is in part freed from these salts.

In the second mode of extracting salt from sea-water, we have said, a very smooth plain of sand is formed on the seashore, at such a height as to be covered only at spring tides. In the interval this sand dries in part, and is covered with a saline efflorescence, which is removed, and set by. When a sufficient quantity of this is obtained, it is washed in pits with sea-water, which thus becomes saturated with salt. This water is placed in large shallow leaden pans, the superfluous water is evaporated by the help of fire, and thus fine white salt is obtained. This process is followed on the coasts of the department of the Channel, near Avranches.

It is said too, that the sea-water may be concentrated by freezing, the part that is frozen containing much less salt than that which is not: but in this way it cannot be concentrated beyond sixteen or seventeen degrees.

The process of congelation cannot be employed for brine-springs that contain sulphat of magnesia, because this salt decomposes the muriat of soda at so low a temperature; sulphat of soda being formed, with muriat of magnesia, a deliquescent salt, that impedes the crystallization of the muriat of soda, and injures its quality.

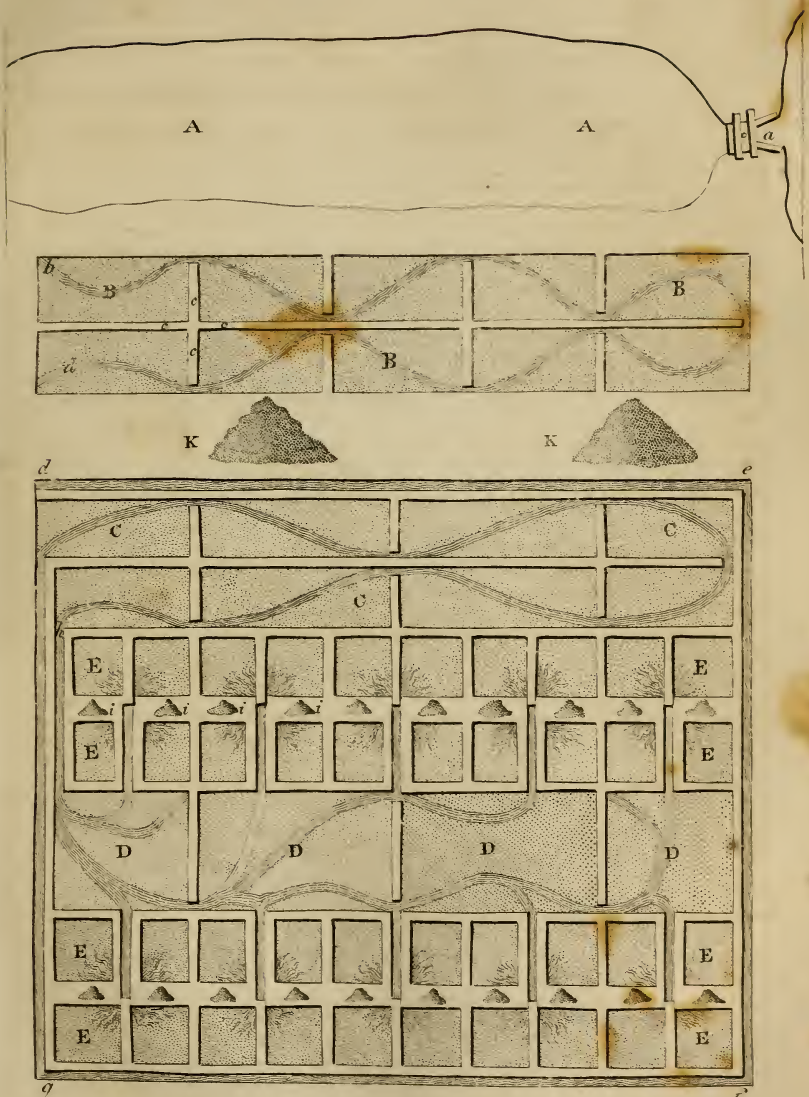
Another process was employed by the Romans in their salt works at Cervia and Ostia. They piled up the salt in heaps, and burned osiers around them. This hardened the surface of the salt so that it had the appearance of being vitrified, and the rain that fell slid off, without dissolving any of the salt. The water in the heap, being also prevented from evaporating by it, carried with it, as it drained off, all the deliquescent salts, and thus rendered the salt itself more pure and dry.

Lastly, at Walloe, in Norway, graduation houses are employed to concentrate the sea-water, which is said to be there at five degrees. By this mean, and the addition of a little Northwich salt, it is brought to the strength of thirty-two degrees, and evaporated in furnaces, as will be described below.

When the water of brine-springs is sufficiently impregnated with salt to contain at least fifteen parts in a hundred of water, that is to say, is at fifteen degrees, it is subjected directly to evaporation. The pans or basins in which this is performed are sometimes of lead, but more commonly of iron. They are very large,

BRINE PITS.

Plate XIV.



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but shallow. Their bottom is flat and smooth, though composed of several pieces; but these pieces of iron have projecting edges on the outside of the pan, which are fastened together by screws, so as to form a very secure and even joint. During the evaporation, sulphat of lime is deposited, which must be removed with care. Little flat tin pans are placed on the borders of the large pan to receive this, and are removed when the salt begins to crystallize; but this method is insufficient. Toward the end of the operation the salt mixed with sulphat of lime begins to adhere to the bottom of the pan, and forms a crust not easily removed. Mr. Nicolas has proposed, to dissolve this in water holding but little salt in solution.

This crust, which contains a great deal of sulphat of lime, is so hard, that it is frequently thrown away as useless. Mr. Unger has turned it to considerable advantage, by powdering it under stampers, and dissolving the salt it contains in some of the water of the same brine-springs, which is thus rendered much stronger. These crusts are produced by the salts, which the water lets fall on that part of the pan, where it is converted from the liquid into the aëriform state. If it were evaporated without ebullition, this would not take place.

Mr. Cleiss, inspector of the salt-works of Bavaria, has lately introduced at Moyenvic a method of evaporation, which appears to prevent most of these inconveniences.

The pans are composed of square plates of cast iron, of 4 millimetres (1.573 line) in thickness, and 4.76 centimetres (18 inches) long on each side. These plates are joined by their edges, which are turned downward, and consequently without the pan; and they are firmly united by a piece in the form of a square gutter, which receives the edges, and is secured by a great number of screws.

An evaporating-house is composed of six pans, of this construction, disposed in two rows; but these pans have different uses, which require a particular arrangement.

That in the middle of the back row is the smallest; and it has no particular fire-place, but it is heated by the junction of the chimneys from the other fire-places. The salt water deposits its impurities in this, which is called the small pan.

From the small pan the salt water passes into the graduating pan, which is lower than the first, and placed in the middle of the front row. The water is there kept in a state of constant ebullition, is concentrated in it to 20 degrees of the hydrometer, and deposits a part of its sulphat of lime.

From the graduating pan the salt water passes into the preparing pans, which are lower than it, and placed at the two extremities of the back row. In these it is also kept constantly boiling, is completely concentrated, and deposits all its sulphat of lime. It is then passed into the crystallizing pans, which are still lower than the preparing pans, and placed at the two extremities of the front row. In these the water scarcely boils, and the salt crystallizes.

Each pan, with the exception of the small pan, has a particular fire-place, the chimneys of which pass round the sides of the pan, and unite under the small pan, by which means there is little heat lost.

These pans are placed two and two in chambers of wood, the joints of which are well secured, and by which they are completely surrounded. These chambers are low, and their ceilings are perforated in the middle with holes terminating in a tube, by means of which the aqueous vapour is disengaged with rapidity. The chambers for the preparing and crystallizing pans have their ceiling pyramidal, or in the form of a hopper reversed, while that for the small pan and the graduating pan is horizontal.

The saline waters are passed successively into these four kinds of pans; and the workmen go into the chambers, in the midst of the vapour, to open the communications. This operation is performed every six hours, and the water in each pan is restored to the level at which it stood six hours before. Every three hours the salt in the crystallizing pans is collected, and is brought with scoops to elevations on the front edge of the crystallizing pans, where it drains. It is afterward carried into drying rooms, which surround the outside of the chambers. These are spaces covered with iron plates, and warmed by heat-tubes leading from the fire-places.

Once a week they take away the sulphat of lime, throw out the mother-waters, and break the shell, that is to say, the incrustations of salt which adhere to the bottoms of the pans. Every three weeks the work is entirely stopped, to repair the pans, an operation which is performed by the workmen themselves.

It has been found, that this method of evaporation affords a saving of more than one third of the fuel.

An improvement has lately been made

in this process at Dieuse: the small pan has been suppressed, and the drying rooms have been replaced by auxiliary pans, in which a coarse salt is made.

The heated drying rooms are useless, when the humidity of the salt arises from the muriat of lime it contains.

Explanation of Plates XV. *and* XVI.

Fig. 1. Plan of the pans.

No. 1. Small pan.

No. 2. Graduating pan.

No. 3. Preparing pan.

No. 4. Crystallizing pan.

The arrangement of the plates of iron, which compose these pans, is shown in No. 2.

a, *a*. Elevation on which the salt is placed to drain, as it is taken from the crystallizing pans.

b, *b*, *b*. Wooden partitions, which separate the chambers.

c, *c*, *c*. A raised wooden ledge, which surrounds the pans.

Fig. 2. Section of the evaporating chamber, which contains the pans 1 and 2, in the line C, D.

d, *d*, *d*. Heat-tubes, which give heat to the small pan, and contribute to heat the others.

e, *e*, *e*. Fire-place for the pans.

i, *i*, *i*. Pillars of cast iron, over the gratings *g*, *g*, *g*, which support the bottoms of the pans.

h. Wooden chamber, which contains the two pans.

k. Opening by which the vapours escape.

Fig. 3. Section of the evaporating chamber, which contains the pans 3 and 4, in the line A, B.

a. Elevation on which the salt from the crystallizing pans is placed to drain.

The other letters indicate the same parts as in the preceding figures.

Fig. 4. Method in which the plates of iron are joined, to form the pans.

a. The iron plate.

b. The iron gutter, which receives the edges of the plates, and is strongly fastened with screws.

i, *i*. Pillars of cast iron, which support the bottom of the pan.

Sometimes the water is evaporated to dryness, but this is rarely done, because for this, the water must contain no muriat of soda. Commonly the mother-water is left, containing chiefly the deliquescent salts, which are muriats of lime and magnesia. These salts, while they increase the bulk of the mother-water, add also to the consumption of fuel, and render the salt obtained bitter and deliquescent.

Mr. Gren, proposes to decompose them in the large way by the addition of lime and sulphat of soda. In this case two substances are precipitated, one of which is insoluble, the magnesia; and the other, the sulphat of lime, is but little soluble. The saline water may then be evaporated entirely, and the salt obtained will be pure and dry.

Lastly, to save fuel is always made an object in these works. The form of the furnaces, and the dimensions of the pans, are calculated to obtain this important end.

In most works where saline waters are evaporated, a smell by no means disagreeable is perceived. This appears to arise from the small portion of bitumen, which is almost always mixed with salt in its mines.

When the saline waters contain but a small quantity of salt, the evaporation of it by fire in its natural state would be too expensive. It must be concentrated therefore by some cheaper mode.

Now it is well known, that, to promote and accelerate the evaporation of a fluid, it should be made to present a large surface to the air. To effect this, the water is pumped up to the height of nine or ten yards, and made to fall on piles of faggots built up in the shape of a wall. The water, distributed uniformly over these by means of troughs, is minutely divided in its descent; and thus experiences a considerable evaporation. The same water is frequently pumped up twenty times or more, to bring it to the degree of concentration necessary This operation is called *graduating*, and the piles of thorn faggots thus erected are termed *graduation-houses*.

These piles are covered with a roof, to shelter them from the rain, are made about five yards thick, and are sometimes more than four hundred yards long. They should be so constructed, that their sides may face the prevailing winds.

Plate XVII. represents a graduation-house at Bex, with the improvements lately made in it by Mr. Fabre.

A. Transverse section of the building.

B. Longitudinal section.

c, *c*, *c*. The faggots or thorns, piled up in two tiers below, and one above.

a, *a*. Wooden troughs, to distribute the salt water over these faggots.

C, C. Plan and perspective view of these troughs.

b, *b*, *b*. Angular notches, through which the water runs out in slender streams, presenting a large surface to the air.

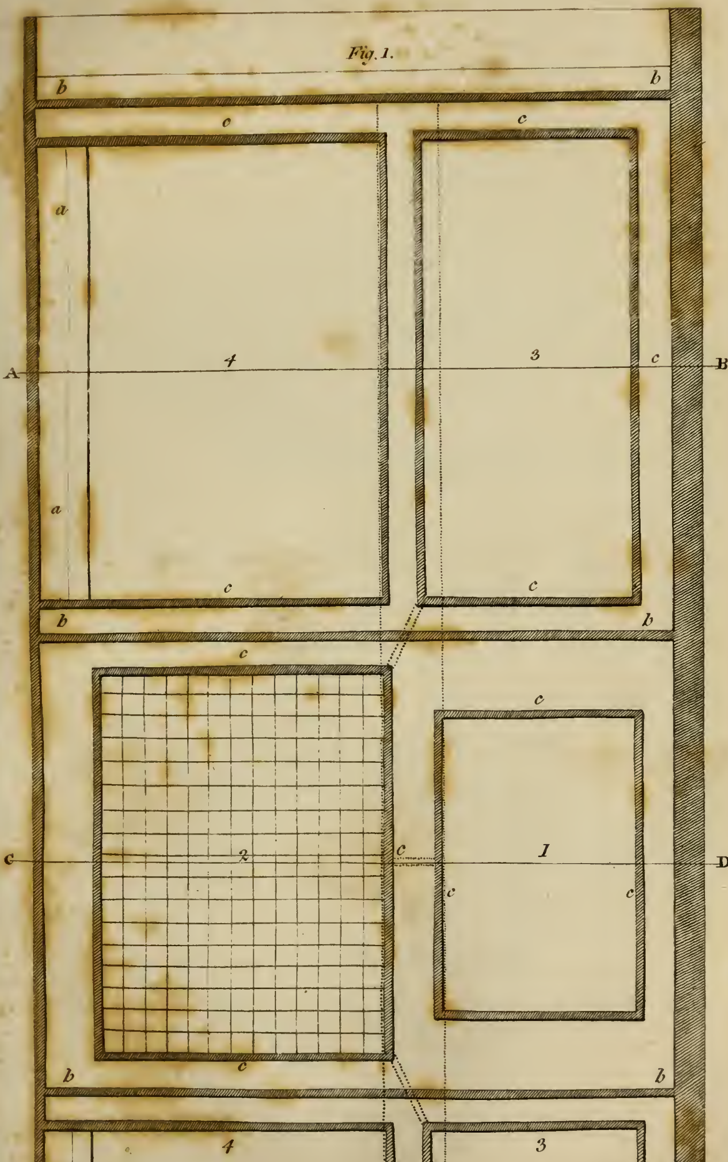
e. Roof, covered with tiles, not laid flat, but raised so as to admit a free circulation of air between them.

d, d. Reservoir, into which the concentrated salt water flows, and from which it

SALT WORKS.

Plate XV.

Evaporating Pans.



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SALT WORKS.

Bavarian Method of evaporating Salt Waters.

Fig. 3.

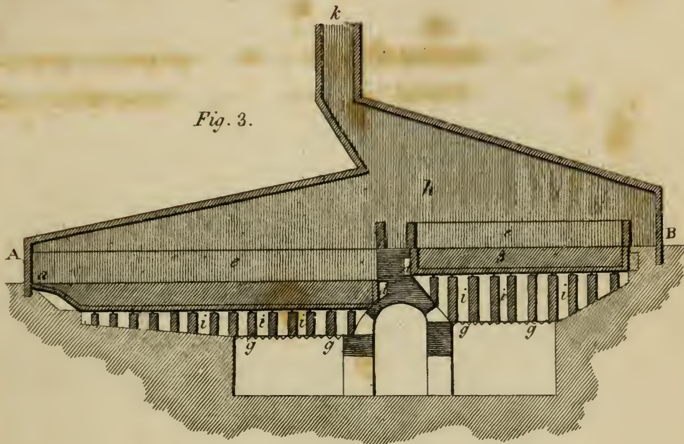
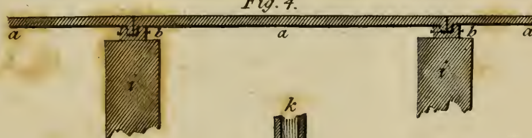


Fig. 4.



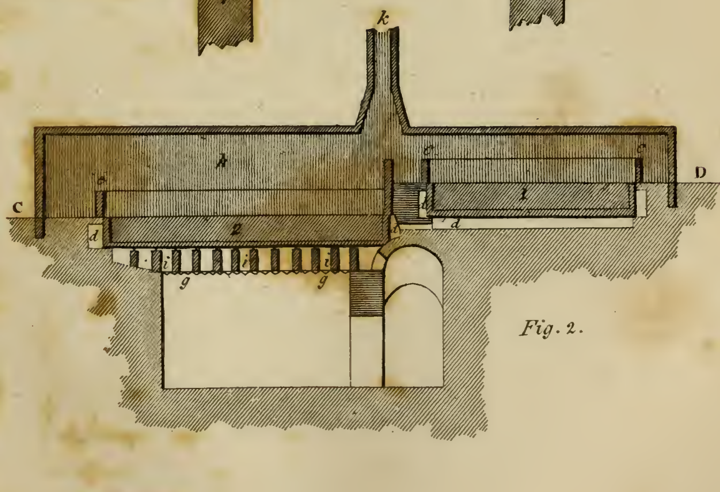
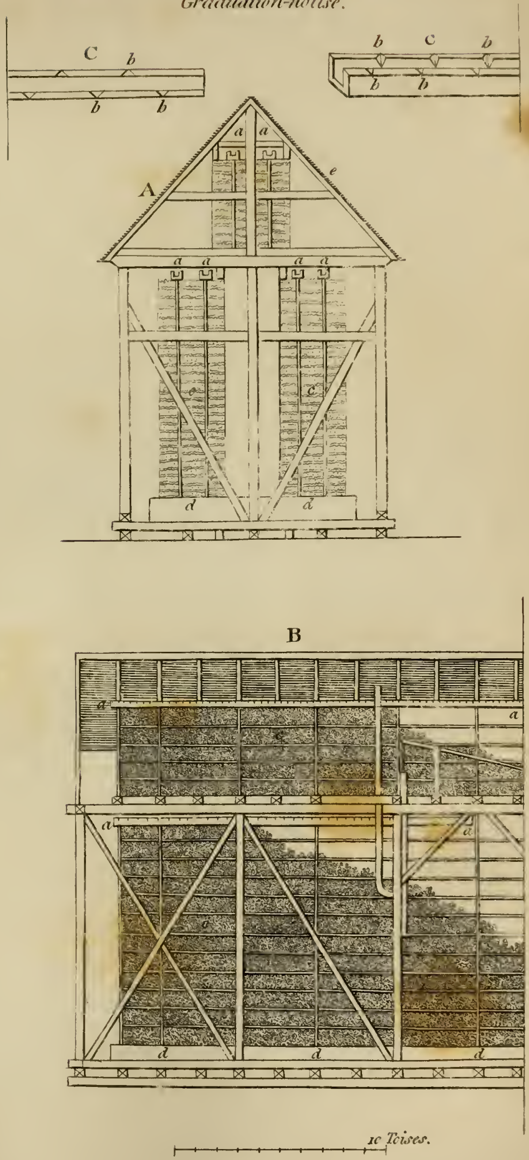


Fig. 2.

SALT WORKS

Plate XVII.

Graduation-house.



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is pumped up to the troughs, to be distributed afresh over the faggots.

The state of the air has a considerable influence on the celerity of the concentration. A cool, dry, and moderate wind is favourable to it: while dull, damp, and foggy weather sometimes even adds to the quantity of water.

As the water is concentrated, it deposits on the faggots a coat of selenite, or sulphat of lime, which at length becomes so thick, that their place must be supplied with fresh ones.

When the water is brought to six or seven-and-twenty degrees of the hydrometer by graduation, the evaporation is completed in pans, as has been described

A process has been adopted at Montier, which, lessening the quantity of fuel employed, renders the operation less expensive. When the water has been concentrated by graduation, and afterwards by artificial evaporation so as to be brought to about thirty degrees, which is near the point of saturation, it is made to flow over a number of strings hanging perpendicularly. These strings acquire a coating of salt, which is removed when about two inches thick. A gathering of salt of this thickness may be made twice or three times a year.

Lastly, at Artern, in the electorate of Saxony, salt has been endeavoured to be obtained from brine-springs by the action of the sun alone, without having recourse to fire. The water is concentrated by graduation: it is then exposed to the sun in very shallow wooden vats, raised above the ground, and provided with a wooden roof, which may be put on or taken off at pleasure.

Weak saline waters may be graduated in some degree by leaving them to stand in deep reservoirs. In this way the lower part of the water is sometimes raised from containing no more than one per cent. of salt to contain fourteen per cent.

Such are the principles of the different methods of extracting or manufacturing salt. In its common state it is in the form of loose granular crystals. These should always be dry: if they be not, the salt has not been perfectly freed from the deliquescent muriats, with which it is often contaminated in its natural state, and consequently is impure; or water has been thrown over it by the vender, to increase its weight, a practice which, we are sorry to say, is sometimes followed by those, who pay more regard to profit than to probity. In some countries it is formed into loaves, by compressing it in a mould with a small portion of water.

The value of salt for culinary purposes is well known: it is likewise of peculiar service in preserving the health of cattle, and particularly in preventing that most fatal disorder in sheep, the *rot*. Besides, salt is an excellent *manure;* as it is equally destructive to weeds and vermin: the most accurate proportion appears to be *sixteen bushels per acre;* but, if that quantity be exceeded, or doubled, it will produce effects diametrically opposite to those intended, and completely check vegetation.

With respect to its medicinal properties, common salt, when taken in small quantities, promotes the appetite and digestion; but, if given in large doses, for instance, half an ounce, it operates as a laxative. It deserves, however, to be remarked, that its useful properties are greatly changed in a state of intimate combination with animal matters: thus, salt-butter and salt-meat, or fish, are less wholesome than those substances when eaten in a fresh state, with a due proportion of that domestic spice; nay, if used too frequently, the former often lay the foundation of tedious maladies, such as leprosy, scurvy, and other cutaneous eruptions.

In addition it may be observed, that almost all graminivorous animals are fond of it, and that it appears to be beneficial to them, when mixed with their food. Wood steeped in a solution of it, so as to be thoroughly impregnated with it, is very difficult of combustion: and in Persia it is supposed to prevent timber from the attack of worms, for which purpose it is used in that country. Bruce informs us, that in Abyssinia it is used as money: and it is very probable, that the pillars of fossil glass, in which the Abyssinians are said by Herodotus to have enclosed the bodies of their relations, were nothing but masses of rock-salt, which is very common in that part of Africa.

Salt was supposed by the ancients to be so detrimental to vegetation, that, when a field was condemned to sterility, it was customary to sow it with salt. Some modern agriculturists, however, consider it as a useful manure, though the experiments on this point do not agree. Probably it is most useful in this way when most impure, and not used in too large a quantity.

The practice of salting ships and other sea vessels with a view to their preservation, says Dr. Mease, in the Archives of useful knowledge, has long been followed in the port of Philadelphia, and found highly beneficial. The following is the mode adopted:

Pieces of boards are dove-tailed be-

tween the timbers and to the outside planks about the floor timber heads: also a little above the listings in the hold, and lastly above the listings between decks. After the vessel has been watered in order to discover leaks, the water drained off, and the timbers are prepared for ceiling, let all the spaces between the timbers and the outside and inside planks be filled with salt, and drove down. The upper rooms must of course be filled before the plank shares are put on. The spaces between the transoms must also be filled.

Salt is only used in vessels built of unseasoned timber, and two of the most experienced ship builders in Philadelphia, gave it as their opinion to the Editor, that a ship built of timber fresh cut and salted as above directed, would far outlast a ship built of the most seasoned timber. The names of several ships built in Philadelphia in 1790, 1792, and since, of unseasoned timber, and salted, were mentioned as being sound to this day.

The effect of the salt is thoroughly to penetrate the planks and timbers, as was evident from a thick incrustation of the salt on the lining of the cabin of a ship thus salted. The lining was five inches thick and painted. The impregnation of the timbers and planks, will of course cause considerable waste of the salt, and will require a renewal of it after every voyage One ship, (the Coromandel,) built in 1806, of 349 tons, required 575 bushels of salt on the stocks; 300 bushels on her return from Calcutta in about 18 months after she was built; and 250 bushels since. The ship Benjamin Franklin, built in 1795, and of about 263 tons, required 350 bushels. The ship Ploughboy, of 287 tons, built in 1800, took 316 bushels. Vessels even of the same tonnage will require more or less salt, as the spaces between the timbers are greater or less.

SALTING MEAT. See Beef.

SAND.—Sand is an assemblage of small stones. It is usually produced by the mechanical division arising from agitation in water. All stones but those of the siliceous order are so soft, that the comminution thus produced is usually carried in them to an extreme degree, so as to form dust, or mud; and their disposition to unite or adhere together commonly produces stones of a different texture from that before possessed by the particles. In this way it appears, that chalks, clays, marls, and other consistent matters may be formed out of harder or more symmetrical materials worn down. But the siliceous earth being not only very hard, but likewise indisposed to adhere together, retains the form of sand, as soon as the parts have become so small as to be deficient in the weight requisite to enable the parts to shake and break each other. Sand is, therefore, always understood to denote a siliceous matter.

The chief uses of sand in chemistry are in compositions for pottery and glass. Some sands are more and some less fusible, according to the various hard stones from which they may have originated. The size of the particles is of some importance in these works. As an alkali in fusion dissolves siliceous earths in less time the greater the surface of action, or, which is the same thing, the finer the particles of sand, this kind is accordingly preferred for vitrifications.

SANDEVER.—This is a saline matter, which rises in the melting pots during the fusion of silex, and appears under the form of scum. See Glass-making.

SAP, or *Water Colours,* are of that nature, that they are capable of being entirely dissolved in water, but are by no means miscible with oils. They are of a viscid nature: whence they stand in no need of any cementing substance, neither do they dry easily for this same reason, and are transparent. All colouring juices and extracts inspissated by evaporation, may be used with this intention; as, for instance, a decoction of Brazil wood prepared with alum, and inspissated; extract of saffron, refined Brunswick green, crystallized verdigrise, an aqueous extract of litmus with the addition of a little alkali, gamboge, sap green, and the inspissated decoction of the green husks of walnuts. Of these, sap green is prepared from the expressed juice of buckthorn berries not perfectly ripe (Rhamnus catharticus, Lin.) by gentle evaporation to the consistence of honey. The sap must be well clarified before it is evaporated. When it is inspissated, as much alum, or, which is still better, sugar of lead, is to be mixed with it by little and little over the fire, as is requisite to produce the finest green colour. A redundancy of these additions is prejudicial. The complete exsiccation must be made with a gentle heat in saucers. The litmus above mentioned, which however contains a blue sap colour, is prepared in the large way in the manufactories of Holland. Ferber gives the following description of it: Archil (Lichen rocella) is to be mixed with urine, lime water, slaked lime, and some potash, in several large cisterns, which must be kept under shelter, and suffered to stand for several weeks. By this means the mass is rendered soft, and passes over to a kind of

fermentation or evolution of its particles, and of the colouring matter contained in them. Now and then it is stirred, and suffered to stand macerating, till the mass is become quite blue, and is converted into a muddy kind of pulp. Upon this the whole mixture is ground in a mill constructed for the purpose, and the pulpy magma dried in moulds. Hither also may be referred the fine sap-blue discovered by Dr. Struve. In order to make this, a quarter of an ounce of indigo is to be reduced to powder, and triturated in a glass mortar, with two ounces of good oil of vitriol. After this, four ounces of alum are to be dissolved in warm water, to which must be added two ounces of a solution of tartar in water, or as much as is requisite for completing the precipitation. The precipitate is then to be edulcorated and filtered; and when it is almost dry, the above mentioned solution of indigo is to be mixed with it. In this manner is obtained a fine blue colour, void of all acrimony, which may be mixed with water ad libitum; with which silk, leather, and bones may be tinged of different shades; and which with some gum forms also a fine sap colour.

SAP-GREEN. See COLOUR-MAKING.

SASSAFRAS OIL. See OIL.

SAUNDERS' RED. See DYEING.

SCARLET BERRIES, or *Kermes*.—A drug used in dyeing. See DYEING.

SCARLET COLOUR. See DYEING.

SCORIA.—The dross, or imperfectly vitrified and porous substance, that swims on the surface of a metallic mixture, or ore, in the furnace where metals are smelted or refined.

SCORIFICATION.—The reducing of a metal to scoriæ, in order to separate it from some other metal less susceptible of being thus acted on by the fire.

SCOTT'S STILL. See DISTILLING APPARATUS.

SCREW CUTTER. See MECHANICS.

SCREW PRESS. See MECHANICS.

SCREW ENGINE, of *Archimedes*. See ENGINE.

SCREW, *Power of the*. See MECHANICS.

SEA WATER.—The composition, and the means of obtaining salt by the evaporation of sea water, has been mentioned in the article on salt. See also WATER. Several methods have been recommended to render sea water fit for drink, but none answers the purpose except distillation. For this end, various economical plans have been used. See Linn on Hot Climates, and Cutbush's Observations on the Means of Preserving the Health of Soldiers and Sailors.

SEA SALT. See SALT.

SEA WAX. See BITUMEN.

SEALING-WAX, is a composition of gum-lac, melted and incorporated with resins, and afterwards coloured with some pigment, such as vermilion, verditer, ivory black, &c.

There are two kinds of sealing wax generally used; the one is *hard*, for the sealing of letters, and similar purposes; the other *soft*, for receiving the impressions of seals of office to charters, patents, and other written documents.

In order to prepare the best hard *red sealing-wax*, take two parts of shell-lac, with one of resin, and one of vermilion; let these ingredients be reduced to a fine powder; melt them over a moderate fire, and, when they are thoroughly incorporated, form the composition into *sticks*. Seed-lac may be substituted for shell-lac, and instead of resin, boiled Venice turpentine may be employed. A coarser kind of such sealing-wax may be manufactured by mixing equal parts of resin, and of shell-lac (or vermilion and red lead, in the proportion of one part of the former to two of the latter), then proceeding in the manner above directed. But, where large quantities of this wax are consumed both the vermilion and shell-lac are generally omitted, so that it may be obtained at a much cheaper rate.

Black sealing-wax is composed of gum-lac, or shell-lac, melted with one-half or one-third of its weight of levigated ivory black. To prevent the composition from becoming too brittle, Venice turpentine, in the proportion of two-thirds of the above ingredients, is usually added; as it likewise contributes to improve the beauty of the manufacture. These substances being melted, and properly stirred over a slow fire, the liquid is next poured upon an iron plate, or stone, previously oiled, and, while soft, it must be rolled into sticks; which are then exposed to heat, till they acquire a glossy surface.

Uncoloured soft sealing-wax is commonly prepared of bees-wax, 1lb.; of turpentine, 3 oz.; and of olive oil, 1 oz.: these ingredients are carefully boiled in a proper vessel for some time; till the compound become fit to be formed into rolls, or cakes, for use. And, in order to impart to it the requisite colour, one ounce or more of either of the pigments above mentioned may be added, stirring the mass till the whole be duly combined.

SEBACIC ACID, or *Acid of Fat*.—This acid is obtained by the distillation of fat. It is not applied to any use. It exists copiously in rancid butter, lard, &c., and is said to give rise to that peculiar state.

Several methods have been recommended to get rid of it, by using alkali, charcoal, &c.; but none answering the purpose completely.

SELENITE. See GYPSUM.

SEMI-METAL. See METAL.

SHAGREEN. See MANUFACTURE OF SHAGREEN.

SHEEP. Under the article Animals, Domestic, we have given some observations on sheep. The following miscellaneous remarks, are from the pen of Dr. J. Mease, whose extensive and accurate information, render them very valuable.

"In May 1809, Mr. Alexander Stuart, of Beverly, Somerset county, Eastern Shore, Maryland, sheared five sheep, the weights of whole fleeces were as follows. They were the lambs of the preceding year.

	pounds.
No. 1.	$10\frac{1}{4}$
2.	9
3.	$8\frac{1}{4}$
4.	$8\frac{1}{4}$
5.	8
	$43\frac{3}{4}$

At the sheep shearing of Mr. Custis, of Arlington, Virginia, in April 1809, the following sheep were shorn.

Columbus, a tup lamb, by Mr .William Fitzhugh, of Ravensworth, Virginia; weight on hoof $130\frac{3}{4}$ lbs. weight of fleece washed, 5 lbs. 5 oz.

Horn Took, a tup lamb, by Dr. William A. Dangerfield, of Notley-Hall, Maryland, weight on hoof 132 lbs. weight of fleece unwashed, 8 lbs. 9 oz.

Palafox, a tup lamb, by J. Scott, Esq. of Strawberry Hill, Virginia, weight on hoof 163 lbs. wool, unwashed, but very cleanly kept, 5 lbs. 13 oz.

Two ewes, by W. H. Foote, Esq. of Hayfield, Virginia, weight of one on hoof, $91\frac{1}{4}$ lbs. fleece unwashed, 7 lbs. $3\frac{1}{2}$ oz. of the other, on hoof, 92 lbs. fleece unwashed, 6 lbs. 14 oz.

In page 91, of the Archives of Useful Knowledge, No. 1, I stated on the authority of a gentleman who has lately been at Mr. Livingston's that the Merino tup, Rambouillet, weighing at the last shearing (1810,) 155 lbs. Mr. Livingston informs me, this is a mistake; he only weighed 145 lbs.; it was another ram, Clermont, that weighed 155 lbs, with his fleece. Thus, at two years old, he was heavier than his sire, a first rate imported Rambouillet ram. It is to be understood, also, that the weights of Clermont and the other two rams, in 1809, were taken after being shorn. Another of Mr. Livingston's stock rams, Jason, a shearling, in the presence of two hundred witnesses, yielded the present season, a fleece of 11 lbs. 12 oz. This, as justly remarked by Mr. Livingston, "is extremely satisfactory, since it shows we have already brought in this country, the Merino sheep to as great perfection, as they have attained in Britain. Mr. Tollet's heaviest ram's fleece being exactly the same with mine."

The average weight of the ewes' fleeces of Mr Livingston's flock, is from 4 to 5 lbs.; this however referred to the half and three-quarter bloods; the average of twenty-seven, bred ewes, and of seven full bred ewes, which was 5 lbs. 2 oz. was overlooked. Mr. Livingston, says, the lightest ewe fleece weighing 3 lbs. 7 oz. and the heaviest 8 lbs. 12 oz. The average of fleeces, of his full bred ewes, lambs included, was 5 lbs. 13 oz. that of all his ewes, to the number of more than two hundred, half bred included, was upwards of 5 lbs. 2 oz.; a weight which he considers, and very justly, as a noble yield, and very encouraging to those, who seek for quantity as well as quality of wool, and especially when it is considered, that nine-tenths of the ewes had lambs.

Mr. Livingston adds,

"Having given the general average of my ewe flocks, permit me now to present you with a view of some selected ones, not kept up to be shorn, but running with my flock, and having lambs at their sides. The greatest number you have exhibited, from one flock, is eight long woolled ewes from Col. Tayloe. These are indeed fine sheep; but still inferior even in quantity of wool, to the same number of Clermont Merinos. Eight of his ewes $62\frac{1}{2}$ lbs. of wool. All mine were weighed, and booked in the presence of two hundred witnesses; the wool in the yoke, but free from tags, and the sheep as clean, as it was possible for unwashed Merinos to be, having been littered all winter, and kept in clean grass grounds, at all other times, and having been washed by the heavy rains, which fell every day for a fortnight together, till five or six days before they were shorn. The weights of eight of mine under these circumstances were as follows:

		lbs.	*oz.*
No. 1.	weighed	8	12
2.	——	8	6
3.	——	8	4
4.	——	8	
5.	——	8	
6.	——	7	14
7.	——	7	14
8.	——	7	12
		64	14

Average 8 lbs. 1 oz. 15 dwt.

The average of twenty-four, selected from Col. Tayloe's flock, was a little better than 5 lbs. The average of all my full bred ewes taken collectively, was 5 lbs. 13 oz.; and that of my whole flock, of upwards of two hundred ewes, exceeded by some ounces Col. Tayloe's twenty-four The average of half my flock, including the four rams, was 7 lbs. 10 oz. this average struck upon upwards of one hundred sheep. The average of one third of my full bred, and seven-eight bred ewes, was 7 lbs. 3 oz. 12 dwt. The average upon one-third of my three-quarter ewes only, 6 lbs. 11 oz, 12 dwt. It is obvious then, that if I were now to part with half my ewes, retaining only the best, that my fleeces would be as heavy as Mr. Tollet's celebrated flock of full bred Merinos; and that if I was to cull out of my present number, seventy of the best ewes, that their fleece would average seven pounds, which considering the difference in the degree of cleanliness, between mine and the sheep at Rambouillet, would bring them very near to a par: for Mr. Lasteyrie says, they had not yet attained collectively to eight pounds. And yet the sheep of Rambouillet are acknowledged, to be superior to any in Europe, so much so, that Mr. Delessert in a letter of the 9th February last, mentions to me, that prime rams from that flock, were sold at 1500 francs, (300 dollars.) While other prime blooded Spanish Merinos, only sold at from 2 to 300 francs. Lest those who have not seen my sheep, should suppose that these heavy fleeces are inferior to the lighter ones, of other flocks in quality, I need only observe, that the Rambouillet fleeces, from which mine are derived, are the finest in Europe. That my wool has sold constantly to manufacturers, at two dollars per pound in the yolk, and is purchased with great avidity To you sir, who have seen samples of it, I need say nothing on this subject, since you are well satisfied of its superiority. And in the letter you did me the favour to write, July 2d, 1809, you say, that you have shown the specimens to the members of the Cattle Society, and that it was agreed that none of you, had seen such beautiful samples; and you add, "the staple is double the length of Col. Humphreys' ram, which I had two years, and had a silkiness and wavey appearance, which the other is entirely deficient in."

The following statement, will serve to show the quantitity of provender, consumed by five Merino three-quarter wethers, in England, and their consequent increase in weight. The sheep were exhibited at the Cattle Show of Lord Somerville, in March last, in London; and had been fed by Morris Birkbeck, a well known respectable agriculturalist.

		pounds.
Weight, November 30, 1809,		537
	March 2, 1810, .	670
	Increase,	133

	Cwt.	*qrs.*	*lbs.*
Having eat, of hay, .	10	3	2
turnips,	21	1	20
100 oil cakes,	2	2	20

Notice had been taken by Mr. Dupont, of the remark made by Dr. Mease, "that Don Pedro has very little wool on his legs." The present deficiency in that respect, observable in him, he ascribes to his great age, and says, that when younger, he was clothed down to the hoof, that his progeny carry the same mark, and that he thinks it characteristic, of true thorough bred stock. It is a fact however, that Mr. Smith's ram, had but little wool on his legs, and yet that the highest price was offered for his fleece, by a manufacturer; and further, that the progeny of Merinos of the same cross, differ much in the proportion of wool on their legs. This remark I have often made when examining my own flock, and that of others. It may be well to attend to the circumstance, in order to determine, whether there be any absolute connexion (in the full blood,) between very woolly legs and quality of fleece.

The following account, from the Virginia Argus, of the utility of salving sheep, is recorded as confirmation of that practice already recommended.

Mr. Pleasants.—I have long thought of communicating to the public, a remedy for the cure of the rot, and scab in sheep, which I have made use of with very great success. In the year 1806, my flock was so very indifferent, that from 90 sheep, I sheared only 130 weight of wool, so sorry as to be barely fit to make clothing for young negroes. Immediately after shearing, I made use of the following mixture: Three gallons of tar, and three gallons of train oil, boiled together, to which were added, three pounds of roll brimstone, finely powdered and stirred in. This quantity was sufficient for the above number, and was poured on with a kitchen ladle, from the top of the head along the back bone, to the tail

At the next shearing, (in 1807,) from seventy-eight of the same sheep, I shear-

ed three hundred and sixty pounds, of very good wool, and instead of twenty to twenty-five sorry lambs, commonly raised from my flock, I raised fifty-five as fine as ever I saw. Since this application, I have frequently been asked by my neighbours, where I got such fine sheep. This remedy was taken from an old eastern paper, which I am sorry to say, I have lost or mislaid. It may be necessary to add, that I have continued to make use of this application with the same success, and that when train oil is difficult to be had, any kind of grease, such as is used for plantation leather, will answer. I am Sir, your obedient servant,

J. NELSON."

Mecklenburg, June 13, 1808.

In order to judge of the comparative profit of feeding two breeds of sheep, says the Doctor, the following statement of the weights of seven sheep, of the Irish breed is given. They were raised and fed by Francis Hickman, of Chester county, Pennsylvania, and killed in March 1812, by Joseph Groffe, of Spring Garden.

	Skin. pounds.	*Fat. pounds.*	*Meat. pounds.*
1.	15	26½	115
2.	20	25	149
3.	16½	23½	133
4.	15½	34¼	139
5.	19	22	105
6.	15½	21½	120
7.	16	27	115

The precise cost of feeding the above sheep, cannot at present be ascertained. Indian corn, oats, and hay, were however given in abundance, besides pasture for two or three years. If the facts can be procured, they shall be given hereafter.

On the stall they appeared covered with fat; so fat indeed, that it was difficult to find any flesh, and no greater proof could be required, of the absurdity of a system of cramming, requisite to produce such over ripe animals. One leg weighed 19 pounds!

Weights of Merino Fleeces.

George-town, Kentucky, April 29, 1812. On Tuesday last, William Story of George-town, sheared, of the flock belonging to Story and Nichols, sixteen full-blooded Merino sheep; ten of which were imported from Spain. The product was as follows.

	lbs.	*oz.*
A ram, Judas, ...	12	4
A ram, Don Carlos, . . .	9	12
An imported ewe, . . .	7	
Ditto	7	8
Ditto	7	8
Ditto	10	4
Ditto	8	4
Ditto	8	
Ditto	6	12
Ditto	6	4
A ewe lamb, Sancho, 15 months old, ...	9	
A ram, Palafox, ...	8	8
A ewe lamb, ...	7	8
A young ram, Columbus, ten months old, ...	7	
A young ram, ...	5	
A young ewe, about ten months old, ...	5	4
	125	12

Averaging the flock, including the lambs, about 7 lbs. 14 oz.

The above shearing was attended by about 100 persons.

It is not stated whether the above sheep had been washed previously to shearing. If they had not, some allowance must be made, for loss in weight; even with that deduction, their weights were respectable.

Merinos yield 7½, 8, 8½ and 9 lbs. wool; the animals having been previously washed.

The following additional remarks are taken from Dr. Parry's essay on the merino sheep, in his communications, to the board of agriculture, England, and may be found useful to our farmers.

The merinos in Spain are about five million, which are divided into Trashamantes and Estantes, indicative of the difference in their species. The heads of these animals are large, and their necks long. Their chests are contracted, and are sharp on the shoulders and flat sided. As they are narrow across the loins, their hind quarters are straight and defective. The skins of the merino are remarkably thin, soft, and loose, affording that evidence of a strong disposition to fatten, which many of the farmers call *proof.* The skin in many other respects differs from common sheep. These animals seem absolutely humid in wool. It exists in their foreheads almost as low as the eyes, and on their cheeks; covers their bellies, and envelopes their hind legs, and sometimes their fore legs, down to their very hoofs. The length of the filaments

is from two to three inches; but the wool of the ram is the coarsest and longest; that of the ewe finest and shortest; and that of the wether, in both respects, between the former. They give, upon an average, about 5 lbs. of wool. Of the rams' fleeces in Spain, it is probable that the medium weight does not exceed 7 lbs. The flocks belonging to the monks, in Spain, produce a great variety, as to size, &c. According to a Spanish shepherd, when the fleeces undergo the operation of washing for sale, which is never performed on the sheep's back, but always after the wool is sorted, they lose three-fifths of their weight; this, however, is ruinous. When afterwards scoured by the clothier, a further loss is sustained of about three, or three and a half, in twenty, which amounts to somewhat less than one-third of the original weight of the wool in the full yolk. The average reduction of the merino wool to perfect cleanness is about two-thirds of the original weight of the unwashed fleece. The wool of the merino differs from all other breeds in being of nearly an equal degree of fineness on the shoulder and on the rump. There are a variety of circumstances, which render the merino different from other sheep, as is shewn by M. Pictet, of Geneva.

Fifteen sheep per day to shear is considered in Spain one day's work for a man. Powdered charcoal is dropped on any wound of the flesh of the merinos, and is said to heal it in a short time. After shearing, an ochrous earth is used on the back of the animal, in Spain, in order to prevent the access of air. The lambs are shorn without being previously sweated.

With respect to the different kinds of wool, see Manufacture of Cloth.

On the Rambouillet flock, it is observed, whether housed or folded, they are not permitted to go out to feed till the dew is dissipated; and to this precaution is chiefly attributed their exemption from the rot. With the same view, in moist weather, their hunger is first appeased with dry food. From 30 to 40 ewes are allotted to each ram: both sexes should be at least two years old; but we are told, that, if persons are eager to augment their flocks, the *two-tooths* may be allowed to take the ram without injury, provided the lambs are made to suck other dams, or she goats; it having been found that it is nursing, rather than gestation, which impedes their growth, and lessens their fleece. The wool of the 4th cross of the merino ram with the common ewes, is usually equal to that of the pure race.

There are several publications on the subject of merino sheep, both in this country and in Europe, which we refer to.

SHEEP-FOLD.—The society for the improvement of arts awarded the gold medal to Mr. Plowman, for an improved sheep-fold. The following description we take from the transactions of the society. The model of Mr. Plowman's fold was forwarded to the secretary of the society, with a letter describing its properties and construction. This fold may be also used for swine, with considerable advantage. Where hogs are folded in the usual manner, great difficulties are experienced for want of stowage, for them to feed off winter tares, &c. as they root up every stake or hurdle. Mr. Plowman, however, is certain that his fold will keep them in, and defy their attempts to displace it.

With respect to sheep, one man, he observes, can remove a fold to contain three huudred with ease in five minutes, which, by the old method, frequently takes some hours to accomplish. A number of gentlemen who have used these folds in Europe, among whom is the duke of Bedford, have given their approbation of them. The fold is made on an improved and very simple principle, combining many advantages over the old and expensive method of folding by hurdles; and as the whole fold can be removed with ease at all times, it is found peculiarly useful in feeding off turnips on the land in frosty weather, when hurdles cannot be used; and, as the saving of labour in agriculture is a leading object, he has no doubt of seeing it, in a very few years, generally adopted.

The expense, in the first instance, will exceed that of hurdles, for the same given quantity of sheep; but having had one in use nearly three years, he is satisfied the saving will be very considerable: for, before he adopted this method of folding, he lost from thirty to forty nights folding in the year, owing to the land being hard in dry seasons, such as the two last; which renders folding almost impracticable, as they never can be set without great labour and destruction of hurdles. He is also clearly of opinion, that the stock of sheep will be greatly increased when this method of folding becomes more known; and that it will enable many small farmers to keep from fifty to one hundred sheep, who now are deterred from it, on account of the small quantity of feed they have, not answering to keep a man for that purpose only; but

by this plan, they may keep a boy at three shillings or three shillings and sixpence per week, who can attend on one or two hundred sheep, and move the fold himself without any assistance. In heavy gales of wind it frequently happens that hurdles are blown down, and the sheep, of course, being at liberty to range over the crops, do incalculable mischief; which cannot happen with this fold.

When the fold is wanted to be used on very hilly ground, it is best to begin at the top, and work it down to the bottom, for the ease of removing it, and then draw it up again with a horse. This, however, the inventor has never had occasion to do; for the land in his country is ploughed in a contrary direction, and the fold is worked in the same course as the ridges. By this means, the inconvenience is avoided of crossing the furrows, and they are also a guide to keep the fold in a straight direction.

With respoct to the sheep getting under, he does not recollect that circumstance to have ever happened, nor does he conceive that any land, which is cultivated, can be so uneven as to admit of it.

Description of the Sheepfold.

Plate XIII. fig 1. Shows one division or part of this fence twenty-one feet long, and three feet eleven inches high, composed of the following parts:

A. A top rail three inches deep and two inches thick. B. The upper bar, three inches deep, and three-quarters inch thick. C C, the two lower bars, four inches by three-quarters of an inch, which, with the upper bar, are morticed through the uprights. D D D D, which uprights are oak, three inches by two inches. E, the lower bar, three inches by three. F, an upright bar, with the horizontal bars halved into it. G G, two oak uprights, three by two inches.

Fig. 2. Shows the oak uprights G G. H, the axle-tree, three inches by three, and three feet between the wheels. I, an oak knee, which connects the uprights G G with the axle-tree, by means of two screws and nuts.

Fig. 3. A plan, in which the axle H is shown with two arms K K at right angles to H, which are made to act as pivots to the wheels, when intended to be moved in a direction at right angles to the bars.

Fig. 4 Is a view of the same parts described in fig. 5. The wheels marked W, in all the figures, are of cast iron, and cost three shillings and sixpence each.

SHEEVE. See MECHANICS.

SHELLS.—Marine shells may be divided, as Mr. Hatchett observes, into two kinds: Those that have a porcellaneous aspect, with an enamelled surface, and when broken are often in a slight degree of a fibrous texture; and those that have generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called nacre, or mother-of-pearl.

The porcellaneous shells appear to consist of carbonat of lime, cemented by a very small portion of animal gluten. This animal gluten is more abundant in some, however, as in the patellæ.

The mother-of-pearl shells are composed of the same substances. They differ, however, in their structure, which is lamellar, the gluten forming their membranes, regularly alternating with strata of carbonat of lime. In these two the gluten is much more abundant.

Mr. Hatchett made a few experiments on land shells also, which did not exhibit any differences. But the shells of the crustaceous animals he found to contain more or less phosphat of lime, though not equal in quantity to the carbonat, and hence approaching to the nature of bone. Linnæus, therefore, he observes, was right, in considering the covering of the echini as crustaceous, for it contains phosphat of lime. In the covering of some of the species of asterias, too, a little phosphat of lime occurs; but in that of others there is none.—*Phil. Trans.*

SHELL LIME. See LIME.

SHELL MARL. See MARL, and AGRICULTURE.

SHOES, *how made water-tight.* See WATER-PROOF.

SHOE, *in Farriery.* See FARRIERY.

SHOT, PATENT.—The manufacture of shot has been heretofore mentioned.

Shot manufactories have lately been established or revived, and appear to promise to supersede the importation of English shot. They are manufactured principally from lead found in Louisiana, and shipped from New-Orleans.

Patent shot, as Dr. Black has informed us, are manufactured in England as follows:

A little orpiment or arsenic is added to the lead, which disposes it to run into spherical drops much more rapidly than it would do when pure. The melted lead is poured into a cylinder, whose circumference is pierced with holes. The lead streaming through the holes soon divides into drops, which fall into water, where they congeal. They are far rom being all spherical, many being shaped like pears, and must be picked. This is done by a very ingenious contrivance. The whole is sifted on the upper end of a

long, smooth, inclined plane, and the grains roll down to the lower end. But the pear-like shape of the bad grains makes them roll down irregularly, and they waddle as it were to a side; while the round ones run straight down. They are received into a sort of funnel, which extends from the one side of the inclined plane to the other, and is divided by several partitions, so that it is really the mouth of several funnels, which lead to different boxes. Those in the middle receive the round grains. See LEAD.

SHUMAC, or SUMACH.—The leaves of this plant are used in abundance in several of the manufactures of our country.

It is largely used in dyeing in lieu of galls, as it contains a considerable quantity of gallic acid, in making black morocco, and in ink making. It is hardly necessary to remark, that it is used in the same manner, and for the same purpose, as galls; with copperas or sulphat of iron, it forms a black colour. As galls are scarce, other vegetable astringents are necessary. Hence, also, its use in the manufacture of ink powder. Very good writing ink may be made by using one or two ounces of shumac, half an ounce of gum arabic or senegal, and one pint of water; or a mixture of equal parts of shumac and galls, and the other articles in the same proportion may be used. Pig nut is also a substitute for galls; but shumac is considered superior. Shumac grows abundantly in the United States. See SUMACH.

SILK, is a fibre or thread spun by the silk-worm, to form a nidus for its preservation in the chrysalis state. It is wound off in the manufactories, and afterward joined or spun into thicker threads. We do not possess any explanation of the process, by which silk, which in the body of the insect has the form of a glutinous unorganized mass, becomes consistent, firm, and very strong, in an exceeding short time after it has been drawn out into thread. Anglers have a practice of cutting the body of a silk-worm, and drawing out the whole of the silky contents into a string of a few inches long, which speedily acquires consistence, has the appearance of catgut or fiddle-string, but is more transparent, and is on that account less visible under water when used as a fishing-line. Chappe has made very interesting researches as to the management of this matter. He dissects the vessels out of the silk-worm, washes them with water, and then dilutes their contents by trituration with about one third of its weight of water. By this preparation they could be blown into permanent globes, and otherwise formed. See *Annales de Chimie*, xi. 113.

Silk appears to be a sort of dried gummy matter. It differs from vegetable substances, 1. in affording ammonia by distillation: 2. in affording nitrogen gas by treatment with nitric acid: 3. in affording a peculiar oil, which is separated from it when the nitric acid converts it into oxalic acid, as has been shown by Berthollet. It seems to be a compound, consisting of a vegetable mucilage, with a peculiar animal oil, which renders it pliant, ductile, and elastic.

Silk is naturally coated with a substance, which has been considered as a gum, to which it owes its stiffness and elasticity: that which is most commonly met with in France contains, besides, a yellow colouring matter.

Most of the purposes for which silk is employed, require that it should be deprived not only of its colouring matter, but also of its gum. Both these purposes are answered by means of soap, and the term scouring is applied to this operation, by which it acquires its suppleness and whiteness. The scouring ought not to be so complete for silks which are to be dyed, as for those which are intended to remain white; and a difference ought even to be made, according to the colour we mean the silk should have.

This difference consists chiefly in the quantity of soap employed: thus, for common colours, it is generally thought sufficient to boil the silk for three or four hours in a solution of twenty pounds of soap for each hundred of silk, taking care to fill up the kettle with water from time to time, that there may be always a sufficient proportion of fluid. The quantity of soap is increased for those silks which are to be dyed blue, and more especially for those that are to be scarlet, cherry-colour, &c.; because for these colours the ground must be whiter than for such as are less delicate. In treating of each colour, the quantity of soap proper for the silk intended to receive it, is mentioned.

When silk is to be employed white, it undergoes three operations. The first is called by the French dégommage, and by our workmen shaking over; it consists in keeping the hanks of silk in a solution of thirty pounds of soap to a hundred of silk: this solution ought to be very hot, but not boiling: when that part of the hank which is immersed is entirely freed from its gum, which is known by the whiteness it acquires, the hanks are turned upon the skein-sticks, so that the

part which was not before immersed may undergo the same operation; they are then taken out of the kettle and wrung out, according as the operation is completed.

The second operation is the *cuite* or boiling. The silk is put into bags of coarse cloth, five-and-twenty or thirty pounds in each bag, which is called a boiling bag (poche); a bath of soap is prepared like the former, but with a less quantity of soap; in this the bags are boiled for an hour and a half, taking care to keep them constantly stirred, that those which touch the bottom of the kettle may not receive too much heat.

The third operation is called bleaching, or whitening, which is principally intended to give the silk a slight cast, to make the white more pleasing; and from which it derives different names, such as china white, silver white, azure white, or thread white. A solution of soap is prepared, the proper strength for which is determined by its mode of frothing when agitated: for the china white, which should have a slight tinge of red, a small quantity of annotta is added, and the silk is shaken over in it, until it has acquired the desired shade. To the other whites, more or less of a blue tinge is given by adding a little blue to the solution of soap, though some had before been put into the boiling.

To prepare the azure, fine indigo is taken; and after being well washed two or three times in moderately warm water, it is ground fine in a mortar, and boiling water poured on it: it is then left to settle, and the liquor alone is employed, which retains only the most subtile parts: this is called azure A small quantity of the liquor of a fresh vat of indigo may be substituted for azure.

At Lyons, where they make a more beautiful white than at Paris, no soap is used in the third operation; but after the second, the silks are washed, fumigated with sulphur, and azured with river water. In this method it is of importance to employ very clear water.

When the silk has become very uniform, and has acquired the desired shade, it is wrung out and dried.

The white obtained by these means is not yet sufficiently bright for the silk intended for white stuffs; but must still be exposed to the vapour of sulphur.

As soap seems to impair the lustre of silk, the academy of Lyons, in 1761, proposed as the subject of a prize dissertation, to find a method of scouring silks without soap; and the prize was adjudged to Mr. Rigaut, of S. Quentin, who proposed substituting for soap a solution of soda, or carbonat of soda, so much diluted with water as not to injure the silk; but some inconvenience must have attended the practice of this method, as it is not adopted, though generally known, and easy of execution.

The Abbé Collomb has published some observations highly worthy of attention, respecting the scouring of silk by the action of water alone. Having perceived, that a skein of yellow silk, which he had boiled for about three hours in common water, had lost nearly one eighth of its weight, he repeated the boiling twice, and thereby brought the diminution to nearly one quarter.

The silk which has suffered this loss of weight still retains a yellow or rather chamois colour, which renders it unfit for white stuffs, or for such as are intended to receive any colour the beauty of which depends on the whiteness of the ground upon which it is applied: but it takes those colours very well, which cannot be injured by the tinge it retains; thus the black which it took seemed preferable to that of silk scoured with soap.

The silk remains very firm and strong after this operation; the threads of it, compared with similar ones scoured with soap, supported weights which broke the others.

Eight hours of brisk ebullition are required to dissolve the whole gummy coat of silk, and it thereby loses a little more than one fourth of its weight; but the boiling ought to be continued longer when the barometer is low, because the greater the weight of the atmosphere, the higher is the degree of heat at which water boils.

This consideration led Mr. Collomb to try the effect of boiling silk in Papin's digester; and he found, that only one hour and a quarter were required to complete the solution of the gummy coat, although the degree of heat must have been inferior to that which produced many of those effects observed by philosophers in that concentrated kind of ebullition.

Berthollet says, that he saw a pattern of silk stuff scoured by Mr. Collomb: it seemed to have the qualities which he mentions; but it had less suppleness and softness than silk scoured with soap.

The substance taken from the silk in the scouring, appears to be of an animal nature, and therefore the soap-suds used in that operation soon become putrid; when separated from the silk, it is easily dissolved in water, but not in alcohol. Though not of a vegetable nature, it may with considerable propriety be called a

gum. That part which gives it the yellow colour, is soluble in alcohol, and when it is separated the gum becomes brown. It is not improbable, that this colour is occasioned by the heat, to which it is exposed in the boiling, because when only the yellow colouring part, is separated by Mr. Beaume's process, which will presently be described, the silk is whitened.

In Mr. Collomb's process, the gum is separated, and takes with it only some of the colouring particles; and in the process of scouring by soap, the gum and the yellow colouring particles, are carried off together.

Berthollet boiled some yellow silk, in a retort, where, as the vapours did not escape so freely, as from an open vessel, a degree of heat must have been produced, superior to that of water boiling, in the open air. After having been boiled for four hours, the silk has lost one-fourth of its weight, but it has almost entirely retained its colour.

The same chemist boiled another pattern, in the same way, in a quantity of water, impregnated with common salt; it became whiter, but lost less of its weight, though the degree of heat was certainly increased, by the addition of the salt, which restrained the evaporation of the water: possibly a part of the salt had united with the silk. Experiments might be made with other salts: aud perhaps we should find some, that without injuring the silk, might be more useful in dissolving the gum, and colouring particles.

When the silk is intened for the manufacture of blonds and gauses, its natural elasticity and stiffness, should be preserved: the greatest part of what is produced in France, is of a yellow colour, but it is the white China silk, that is principally used for these purposes: this is so dear, that the French manufacturers cannot vie with the English, from whom they get it, as the English always reserve the finest for their own manufactures. It has therefore been a desideratum, to find out the means, of depriving the yellow silk of its elasticity. Mr. Beaume has solved this interesting problem, but has kept his process secret; some artists, however, to whom he has intrusted it, or who had been led to the discovery, by their own observations, succeeded in the execution of it; but the process appears to be liable to accidents, which by occasioning loss, increase expense: so that hitherto, notwithstanding the advantages it presents, it has not been carried into execution. The following is an account of what has transpired respecting it.

A mixture is made with twelve ounces of muriatic acid, and forty-eight pounds of alcohol, in which six pounds of silk are immersed. This liquor being poured off, as soon as it is slightly coloured, alcohol alone is to be poured over the silk, till no more colouring matter is taken up by it. A mixture of alcohol and acid like the first, is then to be poured on the silk, in which it is to stand two or three days. Lastly, the silk is to be washed in cold water. The muriatic acid must be pure, and not contain any nitric acid, which makes the silk yellow. To give it an uniform white colour, seems to be one of the most difficult parts of the process, especially when the operation takes place on large quantities. There is likewise great difficulty in dyeing the whitened silk, so as to prevent its curling; it ought certainly to be kept constantly stretched, during the drying. The alcohol that has been impregnated with the colouring part, must be again separated from it, so as to serve for subsequent operations, otherwise the process would be too expensive; for this purpose, it is to be distilled by a gentle heat, in a glass or stone-ware vessel.

It appears from the experiments above related, that the muriatic acid, is useful in this process, by softening the gum, and thus assisting the alcohol to dissolve the colouring particles, combined with it.

Mr. Giobert, has lately given another process, for destroying the colouring matter of silk, preserving its gluten, and scouring it at little expense, without using soap.

He employs oxygenized muriatic acid, largely diluted with water, so as to destroy the colouring matter, without acting upon the silk itself, farther than giving it a yellow tinge, its common effect upon animal substances; and this tinge he takes off, by sulphuric acid. After these alternate immersions, the silk may be scoured in boiling water. He confesses, however, that to operate upon the gluten by the acids, so that the water shall carry it off, and yet not to weaken the silk, is an operation too nice, for the generality of workmen.

The preparation with alum, must be considered as one of the general operations in dyeing silk; for without aluming, the greatest part of the colours applied, would possess neither beauty nor durability.

The preparation with alum, consists in

mixing in a tun, or vat, about forty or fifty pails of water, with forty or fifty pounds of Roman alum, that has been previously dissolved in warm water; this must be carefully stirred during the mixture, to prevent the crystallization of the alum.

After having washed and bathed the silk, and wrung it out with the jack and pin,* in order to separate any soap it may have retained, it is immersed in the alum liquor where it is left for eight or nine hours; after which it is wrung out by hand over the vat, and washed in a stream of water.

In the above quantity of liquor 150 lbs. of silk, may be prepared without the addition of any more alum; but when it begins to grow weak, which those who are in the habit of employing it, can easily distinguish by the taste, twenty or twenty-five pounds of dissolved alum, must be added as before, and this addition must be repeated, until the liquor acquires a disagreeable smell; and then it may be employed, in the preparation of stuffs, intended for darker colours, such as browns and marones, till it has lost all its strengh.

The preparation of silk with alum, is always made in the cold, because when the liquor is employed hot, the lustre of the silk is liable to be impaired.

SILK-WORM, or *Phalæna Bombyx Mori,* is a native of China, where it propagates itself on the mulberry-tree, the leaves of which serve as its only natural food. From the labours of this valuable insect, we obtain silk. The worm is hatched from yellowish eggs, the size of which is rather smaller, than that of mustard-seed; and which are laid by a species of white moth, resembling a butter-fly.

When the egg is hatched, after being exposed to a warm temperature, of from sixty to seventy degrees of Fahrenheit, for a few days, a small black worm bursts forth, which is very eager for food, and ought to be supplied with the most tender mulberry-leaves. These will be greedily eaten, for about six days, at which period the worm is seized with a lethargic sleep, for three days; when it changes its skin. The creature now begins to eat again, for five or six days, till it becomes subject, to a second sickness or sleep, of a similar duration A third and fourth stage of equal length succeeds, so, that in about thirty-two or thirty-six days, the silk worm attains its full growth, being in this climate from one to two inches, but, in the warmer countries, from three to four inches in length.

After these four successive revolutions, the insect devours its food with great avidity for five or six days longer; at the end of which it becomes sickly, and in a manner transparent, when it requires no farther nourishment: at this period, it endeavours to find a convenient spot between the branches, in a dark corner, and begins to spin; winding the silk which it draws from its bowels, around its own body, in an egg-shaped, roundish ball, denominated a *cocoon.* In this state, the worm remains for a fortnight, and upwards, inclosed in the centre of its silky habitation, whence it bursts forth in the form of a whiteish moth, the wings of which are marked with yellow or brown lines; each female lays from 3 to 500 eggs, within two or three days, when she dies without tasting any food: and the male generation perishes in 24 hours, after having propagated its species. It deserves to be remarked, that, during the first day of its labours, the silk-worm spins only the exterior, irregular texture, which is known, in commerce, under the name of *floret*, or coarse silk, serving for inferior stockings, gloves, &c.

On the second or third day, it begins to manufacture fine, connected filaments, extending several hundred yards in length; and, after this useful work, the creature completes its task, by forming its oval solid case, that resembles thin parchment, and in which it rests with safety, till it emerges in the shape of a butter-fly.—Those *cocoons*, however, which are intended for the production of silk, ought to be selected within a week, and exposed to a hot oven, in which bread has been previously baked; with a view to prevent the worm from cutting the silk: on the contrary, such as are designed for breeding, ought to be carefully selected, namely, one male to each female: the cocoons of the former, being somewhat pointed at one end, with those of the latter are generally of a larger size.

* This is a contrivance for wringing more strongly, than can be done by the hands alone; the pin introduced through the hank at one end, or into a twist of the cloth, is secured in a fixed position, while the other end or twist is fixed to the hook of the jack, which can be forcibly turned round, by means of a winch connected with it. When the degree of force is not necessary, and the hands only are employed in the operation, it is called, wringing out by hand.

Having thus stated the various changes which silk-worms undergo, we shall proceed to point out, the most proper vegetables for their subsistence. The best adapted for this purpose, are the leaves of the black and white mulberry-tree. As, however, mulberry-leaves cannot always be procured in sufficient quantity, the insects, if kept in a warm place, may be occasionally fed with those of lettuces. The young, (neither moist nor withered,) leaves of black-berries, vines, cowslips, ash, and primroses, have also been advantageously employed for this purpose; and it is asserted, that elm-leaves may be safely given to them; though some breeders observe, that such food inevitably causes their destruction.

In the management of silk-worms, cleanliness is an object of the first importance: hence, to facilitate the rearing of these profitable creatures, in this climate, the Rev Mr. Swayne has contrived an ingenious apparatus, by means of which, large numbers may be bred in a small compass. It consists of a wooden frame, four feet two inches in height; each side being sixteen and an half inches wide, and divided into eight partitions, by means of small wooden grooves, into which are introduced sliders, that may thus be drawn in or out, at pleasure. The upper slide is of paper, and is destined for the reception of the worms, as soon as the eggs are hatched. The two next are formed of cat-gut, the threads of which are about one-tenth of an inch asunder; and are designed for them, when somewhat increased in size. The five lower sliders, are constructed of wicker-work, with openings about a quarter of an inch square, through which the dung descends. Beneath all these are placed paper-sliders, to prevent the excrements from falling on those which are beneath them. For a more detailed account of this contrivance, the reader is referred to the 7th volume of the "*Transactions of the Society for the Encouragement of Arts*," &c. where it is fully described, and illustrated with an engraving.

For the successful rearing of silk-worms, two essential objects ought to be attended to.

1. A sufficient plantation of mulberry-trees.

2. A proper stock of eggs for hatching, obtained from a climate similar to that in which they are to be bred. Besides, it will be advisable to keep the latter in a cool, but not in a cold place, till the tender mulberry leaves are secured from the effect of night-frosts. The room in which the insects are managed, should be lofty, dry, and rather dark than too light. In short, they ought to pass through their different stages of life, in an uniformly warm temperature, not exceeding that of summer heat.

The quality of silk greatly depends on the manner, in which the raw threads are manufactured. In order to wind them off the cocoons, they are immersed into hot water, for a minute or longer, when they are taken out and reeled by means of a machine; the threads are next twisted, and at length woven into ribbons, satins, &c.

The reader may consult the 2d, 4th, 5th, and 7th volumes, of the "*Transactions of the Society of Arts*," &c. in which the various expedients practised by silk-cultivators, are fully related. Some practical remarks likewise occur, in Mr. Bertezen's "*Thoughts on the different kinds of Food, given to Silk-worms*," &c. (8vo. p. 47, 1*s*. Bew, 1789;) a treatise worthy of perusal.

The breeding of silk-worms, says Dr. Mease, was much attended to, before the American revolution, in the United States, and from the success which attended the efforts, of many individuals in various parts of the continent, from Georgia to Connecticut, it was at first thought that silk would be a profitable article to attend to, but mature reflection has convinced us, that our industry can be more profitably directed to other objects. Those however, who may wish to see the mode of breeding silk worms, may consult the 1st vol. of the *Trans. Amer. Philo. Society;* and for observations on the advantages of the culture of silk, *Carey's American Museum*, and a pamphlet published about 1790, by Mr. Aspinwall, in Philadelphia.

In addition to the preceding observations, we have only to add, that if the rearing of the silk-worm was attended to in the United States especially at this period, it would be profitable, and render the country in this respect, independent of other nations. We have seen silk produced from the worm in this country, made into a fabric, equal to the foreign.

SILVER.—Silver is a metal of a pure white colour, very malleable, soft, fusible at a full red heat, but not oxidable by exposure to the air while melted. It is soluble with ease in nitrous acid, and precipitable from its solution in the form of a white curd by muriatic acid, or any of the neutral muriats.

For the ores of silver, and the different modes of reduction, see ORE.

The following are the most prominent characters of this metal.

Silver is a metal of a beautiful white colour, perfectly free from taste and smell. The colour is very distinguishable from that of every other metal, being a pure brilliant white, free from any other admixture of hue. Its specific gravity, when simply fused in mass, is about 10.4, which is somewhat increased by hammering or lamination, but less so than most other metals. It is a soft metal, being easily scratched by copper. It is considerably elastic, and when hardened by alloying, is highly sonorous, and even in small quantity much increases the sonorousness of the alloys of COPPER, as mentioned under that article. Silver is one of the most extensible metals that we are acquainted with; its ductility is only less than that of gold, in consequence of which it may be beaten out into extremely fine leaves, and drawn out into wire thinner than the finest human hair. For this latter purpose, however, a small alloy of copper is found necessary, though less than that of standard silver, which is one-twelfth. Hence the silver procured from the silver and silver-gilt wire used for laces, embroidery, and other ornamental purposes, bears a higher price than any other usually met with. This metal is also very tenacious, so that a wire a tenth of an inch diameter will support about 240 lbs. without breaking.

Silver, when quite free from alloy, melts in a moderately intense red-white heat, so that a plate about the dimensions of the thinnest pasteboard, will scarcely support the fullest heat of a very brisk fire in a common grate. When in fusion, if pure, the surface is most strikingly brilliant and beautiful, and like a white polished mirror; but as it congeals, it becomes of a clean dead white. If cooled hastily, the surface as it fixes shoots up into small irregular projections with some little force, so as to disperse a few particles of that part of the metal still in fusion. Hence, in the delicate business of the *assay*, arises the precaution of cooling melted silver very gradually while it is fixing. Pure silver is not sensibly volatilized by being kept in a heat not much above its melting point for any length of time, though when mixed with another metal which is itself volatile, either in the metallic or oxided state, a little of the silver is then dissipated. Silver is a *perfect* metal, that is, it does not oxidate by being kept in fusion whilst exposed to air. This position however, though sufficiently accurate for all practical purposes, requires some limitation; for when this metal is intensely heated with access of air, the support on which it stands gradually becomes yellow, owing to the formation of an oxyd of silver.

The pure oxyds of silver are reducible to metallic silver by mere heat, when not in contact with any earth or other substance with which they can vitrify. Under the blow-pipe, silver, when intensely heated, emits copious fumes, which will render brown a surface of gold exposed to it, and consist of the silver volatilized by the extreme heat. The pure oxyd cannot be prepared by mere heat, but is readily furnished by the precipitation of the acid solutions by an alkali. In this state it is insoluble in water, free from taste, and cannot be sublimed; but when heated *per se*, it returns to its metallic state, except the part immediately in contact with any earthy matter which becomes fixed by vitrifying with it.

Silver is nearly unalterable by simple exposure to air and moisture, so that it is incapable of rusting. A polished surface of this metal will remain bright for some time in a pure air, free from sulphureous and animal vapours; by degrees, however, the metal becomes dull and brownish, and after a while, a very slight coating forms on its surface, which rubbing with any soft powder will take off, and the brightness will be restored with scarcely any loss of weight, the outer coating long protecting the metal within from further change. This takes place, however, much more rapidly when the silver is alloyed, (as in the common plate) than when pure.

In general. the *tarnish* of silver is in too small a quantity to be examined, but when this metal has been exposed for a very long series of years to the common air of towns and inhabited places, the corrosion penetrates deeper, and the altered part will readily peel off. This, however, is not the pure oxyd, but the sulphuret, as was ascertained by Proust, the properties of which will be afterwards described, so that we know of no simple oxyd of silver formed spontaneously in the air.

Water has no effect whatever on silver at any temperature, and is not decomposed upon it.

Though silver at no temperature undergoes combustion by simple contact of common air, or oxygen gas, yet it burns totally and most beautifully in the electric and especially the galvanic circles.

The sulphuric acid has no effect on silver in the cold in any state of dilution, but when the acid is concentrated and a boiling heat is employed, effervescence begins, an abundance of very pure sulphureous acid gas is given out (as with this acid and mercury) and the metal is changed to a white pulverulent mass, or

is dissolved entirely into a dense clear liquid if the quantity of the acid is about four times that of the silver, which latter should be added in small shreds or grains.

This solution is extremely styptic and requires an excess of acid. By evaporation it furnishes small white brilliant needled crystals.

The sulphureous acid has no action on silver, but readily combines with its oxyd. This solution crystallizes spontaneously in small pearl-gray brilliant grains unaltered by light.

The nitric acid dissolves silver easily, and in large quantity, and is the acid constantly employed for this purpose in the arts. The concentrated acid should be diluted with from two to four parts of water. Very soon after the silver is immersed in the acid, a strong effervescence begins, much nitrous gas is given out, which forms a copious orange-coloured vapour as it escapes from the vessel, and the acid assumes a light blue-green colour, which is independent of any copper which the silver may contain, and is owing to the solution of a portion of the nitrous gas in the acid. If, however, the silver contains copper, this increases the blueness, and the colour remains after the solution is cold and saturated, which is not the case when the silver is pure. A considerable heat is excited by the action of the acid on the silver, which also much assists in the rapidity of the process, so that where the quantity of each is at all considerable no artificial heat is required. The solution is made very conveniently by putting the silver (granulated or in shreds) into a decanter or matrass, adding the acid, and to it about four parts or more of *hot* water, and setting it under a chimney to draw off the fumes. The solution then begins almost immediately, and goes on with increasing violence for a time and then continues steadily till the silver is dissolved or the acid saturated, without requiring any artificial heat.

When the silver contains a little gold, as is the case with a large proportion of the standard silver in use, the gold is left behind after the solution of the silver in the form of a black powder, which, when collected, and fused with a little borax, appears in its reguline state.

When the nitric acid contains either muriatic or sulphuric acid a milkiness is perceived as soon as the effervescence begins, owing to the separation of the first portions of the dissolved silver from the nitric acid in the form of an insoluble sulphat or muriat. Where the quantity of these foreign acids is but small, it does not materially impede the process, and these insoluble salts, after the nitric acid is fully saturated, fall to the bottom by standing at rest for some hours.

Liquid nitrat of silver is perfectly clear and colourless in case the silver was pure; but if standard silver be employed, the colour is a light blue, owing to the presence of copper. When at all concentrated, its taste is excessively styptic and bitter, and it rapidly corrodes the skin of the tongue. Even in extreme dilution, the bitter styptic metallic taste is very sensible, and it remains for a long time in the palate. This salt blackens every part of the skin, and all other animal matters. The blackness, however, does not come on till after the part has been exposed for some time to the light, and is therefore particularly hastened by sunshine; but the mutual action between the salt and the skin, is so sudden, when the solution is concentrated, that a few seconds of contact will be sufficient infallibly to produce the effect, though it be carefully washed off immediately after. This stain lasts for several days, and only goes off by the natural change of the cuticle, so that in dead animal matter it is indelible.

The blackness is owing to a reduction of the metal in excessively minute particles; for when examined in a strong sunshine with a powerful microscope, the particles of metallic silver may be distinguished. See Ink, *Indelible.*

Most vegetable substances are also stained by this salt, though in a less degree, and less permanently.

When this solution is sufficiently concentrated, it readily crystallizes on cooling. The form of these crystals is generally six-sided, or square thin plates, often ranged like the sticks of a fan, and forming very beautiful groups. This salt is not deliquescent, and is soluble in about four parts of cold and much less of boiling water.

It appears to contain but little water of crystallization, for when moderately heated it melts, and may be kept at that state without losing more than one per cent. of its weight. By cooling it concretes into a dark gray mass, which is the nitrat scarcely altered, and when redissolved in water, will again crystallize. This gray solid nitrat forms a very valuable caustic for the use of surgeons, and for convenience is cast in oiled moulds into pieces about the size of pencils, which are called *lunar caustic*, or *lapis infernalis.* This is actually prepared, however, without the trouble of crystallization, simply by evaporating the nitrat of silver to the proper degree, and cooling the residue in the proper moulds. When one of these pencils

is broken across, it presents a radiated texture. The degree of causticity of this substance is by no means so powerful as that of the solid alkalies, for it corrodes the cuticle with difficulty, and it requires some hours to destroy the surface of the flesh.

The composition of nitrat of silver is given by Proust, as follows:

Silver	64	70
Oxygen	6	
Nitric acid	-	30
		100

Nitrat of silver detonates most violently with phosphorus.

Phosphorus will also reduce the nitrat of silver in the moist way.

Hydrogen also rapidly reduces the nitrat of silver, and during its reduction it passes through various shades of brown, till it acquires the metallic lustre.

Nitrat of silver is also reduced very readily upon charcoal by the sun's rays, or by exposure to a heat of boiling water without the assistance of light.

Silver is precipitated from its nitric solution by mercury. If the solution contains both silver and mercury, and the precipitating metal be also a compound of mercury and silver, a curious and beautiful precipitation of a brilliant alloy of these two metals is deposited in an arborescent form, which has been called the *Arbor Dianæ*, or *Silver Tree*.

Nitrat of silver is decomposed by the fixed alkalies, pure or carbonated, and by the alkaline earths.

Ammonia first gives a precipitate which it speedily redissolves, and forms with some particulars in the management the fulminating silver, which will be presently described. Carbonat of ammonia gives a white or a dark precipitate, according as it is more or less saturated with carbonic acid. All these oxyds turn blackish by exposure to light.

Many other metals also separate silver from its solutions in this and other acids, and particularly copper, which is employed largely for this purpose by the refiners. In assaying gold (as mentioned under the article Assay,) the cupelled button of gold and silver is treated by nitric acid to dissolve out the silver and leave the gold pure. After this process (which is called *parting by aquafortis*,) a nitrat of silver is left, which, when a sufficient quantity is collected, is thrown into a copper bason, sometimes also with pieces of copper immersed, and the silver is reduced in its perfect metallic state in the form of thin brittle leaves, and the bason now contains nitrat of copper. The latter again decomposed by lime yields the pigment *Verditer*.

Nitrated silver is also decomposed by a great variety of alkaline and earthy salts, particularly by the sulphats, muriats, phosphats, &c.; that is, by all those whose acids, united with silver, produce an insoluble salt.

Several of the metals are found to combine with the acids in two proportions, one, where the ingredients are in mutual saturation, or else where the acid is in excess, and the other, where the metallic oxyd predominates.

All the solutions of silver are blackened immediately by sulphuretted hydrogen, either in the gasseous or liquid states, and all the solid sulphurets produce the same change on silver, as will be presently mentioned.

A compound acid, extremely useful for dissolving silver when mixed with copper and some other metals, has been discovered by Mr. Keir. It is formed by dissolving one part of nitre in about eight or ten parts by weight of strong sulphuric acid. When pieces of silver are thrown into this acid (undiluted with water) and a heat of from 100° to 200° is applied, an effervescence of nitrous gas takes place, and the silver is dissolved. This makes a very dense heavy solution, which readily concretes by cooling, but may be moderately diluted with water, without becoming turbid. This compound acid (which may be termed the *nitro-sulphuric*) dissolves about a fifth or a sixth of its weight of silver, and with much more ease than the sulphuric acid singly would do. The quantity of nitrous gas given out in the process seems to be less in proportion as that of the nitre is greater. The nitro-sulphuric acid, undiluted, also oxydates and partly dissolves tin and mercury, but it hardly touches copper, lead, gold, or iron. Hence it is particularly useful in recovering the silver from the surface of any silver plated metal, which is an object in large manufactories of plated goods, and was usually done from copper plate at Birmingham (England) by more expensive methods.

Sulphuric acid impregnated with nitrous gas (a combination first noticed by Dr. Priestley) dissolves silver with effervescence as soon as heat is applied, the solution becomes of a violet colour, and much nitrous gas is disengaged. By moderate dilution, a white saline powder falls down, which is redissolved in more water. The undiluted solution saturated, and set in a cool place, readily congeals, but when diluted slightly it gives foliated crystals.

The carbonic acid has no action on silver or its oxyd; but a carbonated oxyd, insoluble in water, is formed by precipitating the nitrat, or any other solution, by a carbonated alkali.

Muriatic acid is usually said to have no action on reguline silver either hot or cold. This is the fact (generally speaking) for the action in a moderate time is so small that the silver hardly appears corroded, though after a certain time and particularly with the assistance of heat, the metal is converted into an insoluble muriat, and the remaining acid, which is proportionally weakened, retains scarely a particle of the muriat in solution. But the oxyd of silver readily unites with this acid, and forms a white curd-like mass, insoluble in water. This combination, however, is more frequently made by the mode of precipitation, and occurs whenever muriatic acid, or any alkaline or earthy muriat is added to any salt of silver except the prussiat. In this case if the solutions are at all concentrated, at the moment of mixture a white curd-like substance separates, and speedily sinks to the bottom, which is the *muriat of silver*, or *luna cornea*. This precipitation is one of the most familiar to chemists, for being perfectly insoluble in water, it shews itself when the most minute quantities of muriatic acid and silver are present, and thus it forms a most useful test for either substance.

The acetous acid has no action whatever upon pure silver, but it combines easily with its oxyd. Acetite of silver is readily formed by adding acetite of potash to nitrat of silver, or more simply by boiling this acid on the carbonated oxyd of silver.

When silver is treated with nitrous acid and alcohol, a white powder is deposited, which fulminates with extreme violence, and which, from the analogy with the fulminating mercury produced in the same way, is probably an oxalat of silver. This preparation was discovered by Mr. Howard, in his attempts to communicate to other metals the same fulminating property which he had given to mercury, and is prepared in the same manner as has been described in the article Mercury.

Mr. Cruickshank, in repeating this experiment, dissolved 40 grains of silver in two ounces of strong nitrous acid diluted with as much water, and on heating the solution with two ounces of alcohol, he obtained 60 grains of a white powder, which fulminated violently. Brugnatelli has given the following method of preparing the same. Put 100 grains of lunar caustic in a glass, and pour on them first an ounce of alcohol, and then as much concentrated nitrous acid. The mixture grows hot, boils, and an ether is visibly formed, which flies off in vapour. By degrees the liquor becomes milky, and is filled with small white flocculi. When the liquor has thickened by this precipitation, add cold distilled water to suspend the ebullition, otherwise the precipitate would be re-dissolved; then collect the powder, and dry it with a very moderate heat. This is the fulminating silver, and amounts to more than half the weight of the lunar caustic employed.

One grain placed on a lighted coal detonates with a deafening report, if touched with the end of a glass tube dipped in sulphuric acid, or with the electric spark, so that in violence it greatly exceeds the fulminating mercury.

The combination of oxyd of silver with ammonia, is remarkable for affording the most violently detonating substance yet known. This was discovered by Berthollet, and considering the multitude of experiments in which ammonia has been employed along with the salts of silver, it is rather surprising that it was not sooner discovered by some serious accident.

This fulminating ammoniacal oxyd is prepared in the following way, according to Berthollet the inventor, and the directions given by Dr. Higgins: Dissolve any quantity of silver, perfectly free from copper, in as little nitric acid, moderately dilute, as is sufficient; pour off the clear solution from any black sediment which may be left (and which is commonly gold) and add to it lime water as long as any considerable precipitate falls down. Edulcorate this precipitate, which is a brown oxyd of silver, and then lay it on several folds of filtering paper, or spread it out on a single paper laid on a smooth dry lump of chalk, and dry the precipitate thoroughly in the open air. Set this oxyd by for use in a well-corked phial. About one and one-sixth of an ounce is obtained from an ounce of fine silver. The caustic fixed alkalies may be used instead of the lime-water, but they do not act with so much certainty. This oxyd dissolved in ammonia, forms the fulminating powder. For this purpose add 10 or 12 grains of this oxyd to about half an ounce in measure of liquid ammonia, perfectly caustic and moderately dilute. This gives a snapping noise, and blackens the whole oxyd immediately, and dissolves either a portion of it only, leaving a black powder at the bottom, or, if more ammonia is used, the whole is dissolved. Pour the clear solution off from the black powder, if any, and expose it in a shallow vessel to the

air. In ten or twelve hours a crystalline pellicle appears on the surface of the ammoniacal solution, which is the fulminating silver, and is composed of a congeries of black shining crystals. Take them out, whilst still wet, and lay them in separate parcels of not more than a grain or two on blotting paper, and let them dry in the air, carefully avoiding to touch them.

This fulminating powder has the following properties: even when still wet, if it be pressed upon with a hammer or any hard body, it fulminates with extreme violence; but when dry, the touch of a slender wire or even a feather, or a heat of about 96°, is sufficient to make it explode. Even a moderate concussion of the air is sufficient, so that a heap may be exploded by the concussion of any other in its immediate neighbourhood. Sometimes too, it will go off in the hand, when carrying from one place to another; so that in fact, when it is once dry, the operator should be prepared for the explosion at any time, even with the most careful handling.

Several serious accidents have happened in preparing this fulminating silver, which shew the necessity of great precaution in the operator; and, as all the circumstances in which the explosion is produced are not as yet known, he should on no account venture to prepare more than a few grains at a time of this dangerous compound.

Silver is capable of uniting with sulphur in various proportions. Artificial sulphuretted silver is a black brittle mass, like the native sulphuret.

A sulphuret, or rather a hydrosulphuret, of silver is formed whenever this metal is exposed to sulphureous vapours, or any liquor containing sulphuretted hydrogen. After a certain time the substance of the metal is deeply sulphuretted, and may be detached in brittle scales. But it takes a great length of time to effect this by mere exposure to sulphureous vapours.

Some of the alloys of silver are important. This metal will unite with some metals perfectly and without losing its malleability; with others it forms a brittle white alloy, but with others it refuses to unite, except in a very minute proportion.

Silver mixed with gold, dilutes its yellow colour more or less according to its quantity. Gold with one-twentieth of silver is sensibly paler, and the debasement of colour proceeds pretty uniformly as the silver is increased. These mixtures are very malleable, though somewhat firmer, harder, and more sonorous than either metal, separately.

Copper is the metal usually employed to alloy silver in the vast quantity of this metal used for coin and plate of all kinds. The standard silver is about eleven parts of silver and one of copper. In this proportion, or even somewhat more of the alloy, the mixture remains nearly as white as pure silver, but is much harder, less fusible, and though it remains highly malleable and ductile, so as to bear being extended into any shape, and wrought in a thousand different ways, it is certainly less ductile and malleable than a metal with less alloy, since so much finer a metal is required to be used in making silver wire and leaf. On account of the hardness given by the copper alloy it is much better fitted to take a fine impression, and is therefore particularly useful in coining, and in all domestic implements.

An alloy of these two metals has been used in France for coinage for many years, and called *monnaie de billon*, in which the silver is from one-twelfth to one-fourth of the mass, and which looks like half-whitened copper, or degraded silver. Being on the whole an injudicious compound it is mostly now laid aside.

Silver unites perfectly with lead apparently in every proportion, into an uniform malleable mixture, harder and whiter, and less fusible than pure lead, in proportion to the quantity of silver. The necessity of this alloy to the process of cupellation in *assaying* and in refining silver has been already mentioned.

Silver and iron are generally reckoned entirely to refuse to unite in any proportions, and it is certain that when they are melted together, they form, on cooling, two perfectly distinct and separable buttons, the iron at top, and the silver beneath it.

Silver unites with bismuth, zinc, antimony, and some other of the brittle metals, forming brittle alloys which have not been much examined, and are of little importance.

SILVERING, *The Art of*.—This art consists in covering the surface of substances with a thin coating of silver. There are two motives for this; in the first place, the superior beauty of silver to that of the cheaper metals; and in the second place its superior wholesomeness to copper, brass, or lead, for culinary purposes, on account of its not being acted upon by vinegar and other weak acids.

The application of silver leaf is made in the same way as that of gold. See Gilding.

As an ornament, silver is far inferior to gold, from its great liability to be blackened by sulphureous vapours, which renders frequent cleansing absolutely necessary; hence it is inapplicable to the purpose of architectural decoration, and is scarcely ever applied except to utensils and ornaments of metal. From the frequent necessity of friction for the purpose of removing the tarnish of silver, it is necessary that it should be much thicker than the most solid gilding, otherwise, after a short time, the silver will be worn off the most prominent parts, discovering to view the copper or brass beneath.

The only metals that are silvered are copper, brass, and very rarely iron.

There are three modes of silvering, namely, by silver amalgam, by muriated silver, and by silver in substance.

Silvering by amalgamation is thus performed:

To a solution of nitrated silver add some plates of copper, which will throw down the silver in its metallic state, and very finely divided; scrape it from the surface of the copper, wash it well, and dry it. Of this powder take half an ounce, of common salt, and sal ammoniac two ounces, and of corrosive sublimate one drachm: rub them well together, and make them into a paste with a little water. Then take the vessel to be silvered, and clean it by means of a little very dilute aquafortis, or by scouring it with a mixture of common salt and tartar. When it is perfectly clean, rub it with the abovementioned paste till it is entirely covered with a white metallic coating; this coating is an amalgam produced by the decomposition of the corrosive sublimate by means of the copper, to the surface of which it applies very closely and expeditiously. The copper being thus silvered over is to be washed, dried, and afterwards heated nearly red, in order to drive off the mercury; the silver remains behind adhering firmly to the copper, and capable of being highly polished.

Silvering by luna cornea.

Prepare the luna corner in the usual manner, by pouring a solution of common salt into nitrat of silver as long as any precipitation takes place, and boiling the mixture; the white curdy matter thus obtained is to be mixed with three parts of good pearl-ash, one part of washed whiting, and somewhat more than one part of common salt. The surface of the brass being cleared from scratches is to be rubbed with a piece of old hat and rotten stone to remove any grease, and then is to be moistened with salt and water: a little of the composition being now rubbed on with the finger, the surface of the metal will presently be covered with silver. Then wash it well, rub it dry with soft rag; and as the coat of varnish is extremely thin, cover it with transparent varnish to preserve it from tarnish. This kind of silvering is very imperfect, and is only used for the faces of clocks, the scales of barometers, and similar objects.

Silvering by Silver in Substance.

There are three ways of performing this. The first is by mixing together 20 grs. of silver, precipitated by copper, 2 drachms of tartar, 2 drachms of common salt, and half a drachm of alum. This composition being rubbed on a perfectly clean surface of copper or brass, will cover it with a thin coating of silver, which may afterwards be polished with a piece of soft leather.

A still better way is that which is called French plating, which consists in burnishing down upon the surface of the copper successive layers of leaf-silver to any required thickness. In this the silver has much more solidity than in any of the former, but the process is tedious, and the junctures of the leaves of silver cannot always be entirely concealed.

The method of plating (in those works to which it is applicable) which appears to be the best of all, is thus performed: one of the surfaces of an ingot of copper is rendered quite smooth and clean, and is sprinkled over with glass of borax; upon this is laid a plate of fine silver, about one-twelfth of the weight of the copper, and the two are carefully bound together by wire; the mass is now exposed to a full red heat, which melts the borax and causes the silver to adhere to the copper; the ingot is now passed through a rolling press, and formed into a plate; both the silver and copper extending uniformly during the whole process, at the conclusion of which the two metals are inseparably fixed to each other. See PLATING.

Copper may be silvered over by rubbing it with the following powder: Two drachms of tartar, the same quantity of common salt, and half a drachm of alum, are mixed with fifteen or twenty grains of silver, precipitated from nitric acid by copper. The surface of the copper becomes white when rubbed with this powder, which may afterwards be brushed off, and polished with leather.

The sadlers and harness-makers, cover their wares with tin for ordinary uses, but a cheap silvering is used for this purpose as follows: Half an ounce of silver, that

has been precipitated from aqua fortis by the addition of copper, common salt, and muriat of ammonia, of each two ounces, and one drachm of corrosive muriat of mercury, are triturated together, and made into a paste with water; with this, copper utensils of every kind, that have been previously boiled with tartar and alum, are rubbed, after which they are made red hot, and then polished. The intention of this process appears to be little more than to apply the silver, in a state of minute division to the clean surface of the copper, and afterwards to fix it there by fusion; and accordingly this silvering may be effected, by using the argentine precipitate here mentioned, with borax or mercury, and causing it to adhere by fusion.

The silvering of pins is effected, by boiling them with tin filings and tartar. The explanation of this effect is difficult. It should seem as if the order of the affinities was changed, by the increase of temperature; so that the tin may be taken up, at a lower temperature by the acid, and give place to the brass at a greater heat. See Tinning.

SILVERING OF GLASS. To silver glass globes: Take half an ounce of clean lead, and melt it with an equal weight of pure tin; then immediately add half an ounce of bismuth, and carefully skim off the dross; remove the mixture from the fire, and before it grows cold, add five ounces of mercury, and stir the whole well together: then put the fluid amalgam into a clean glass, and it is fit for use.

When this amalgam is used for foiling or silvering, let it first be strained through a linen rag; then gently pour some ounces thereof into the globe, intended to be foiled; the mixture should be poured into the globe, by means of a glass or paper funnel, reaching almost to the bottom of the globe, to prevent its splashing to the sides; the globe should then be dexterously inclined every way, though very slowly, in order to fasten the silvering: when this is once done, let the globe rest some hours; repeat the operation, till at length the fluid mass is spread even, and fixed over the whole internal surface; as it may be known to be, by viewing the globe against the light: the superfluous amalgam may then be poured out, and the outside of the globe cleared. See Glass.

SKIN. For the preparation of the skin of animals, for the purposes of manufacture, see the article Leather.

SLAG. Is a technical term used among smelters, and workers in minerals, to express any hard vitrescent, generally coloured and opake mass: produced by the fusion of any stony or metallic mixture. It generally consists of the gangue or matrix of the ore, together with any saline or earthy flux that may have been used. Thus the slag of iron founderies, is for the most part composed of the earthy part of the ore, of the lime used as a flux, and the whole deeply coloured, with a part of the oxyd of iron, which has escaped reduction. A *slag* differs from a *scoria*, in being more dense and more completely vitrefied, whereas the scoria or dross is lighter and porous. When the slag is very opake and heavy, it contains a considerable quantity of metallic oxyd, so that in improving smelting works, it is often worth while to work over again, with fresh reducing matter, the slags of former operations conducted less skilfully. In some parts the slag of founderies, is broken into lumps, and used for mending roads, for which it makes an excellent material when a little worn down, being very hard, and impenetrable by water.

SIMILOR. See Copper.

SIZE. See Gelatin.

SLATE. Slate is a stone of a compact texture, and laminated structure, splitting into fine plates.

The Whitish Slate.

Is a soft friable stone, of a tolerable fine and close texture, considerably heavy, perfectly dull and destitute of brightness, variegated with a pale brown, or brownish yellow. This species is common in many countries, lying near the surface of the ground. It is commonly used for covering houses. It is found near the Lehigh, Pennsylvania.

The Red Slate.

Is of a very fine, elegant, and smooth surface, considerably heavy, and of a very beautiful pale purple, glittering all over with small glossy spangles. This kind of slate is much valued, as a strong and beautiful covering for houses.

The Common Blue Slate.

Is of a fine smooth texture and glossy surface, moderately heavy, and of a pale greyish blue. This is also very common, and is used in most places for the covering for houses.

The Black Slate.

The friable, aluminous black slate, being the Irish slate of the shops. It is com-

mon in many parts of Ireland, and is also found in some places in America. There are other varieties of slate.

The chief purpose to which slates are applied, is that of covering houses; for which it furnishes a strong and elegant roof. As the usual method of slating has, from experience, not proved sufficiently durable, Mr. Richard Elliott obtained a patent in March, 1781, for a mode of covering houses, &c. on a more safe and eligible plan, than that generally followed. His practice consists, in cutting the slates in a rhomboidal form, so as to fold over each other. These are next laid in lime or putty, and fastened to the rafters, on boards, by means of nails or screws, either of wood or iron. This patent is now expired; and as Mr. Elliott's method promises to secure houses, covered with this fossil, more effectually from the effects of rain and moisture, than the common plan, we recommend the former to the attention of our readers; referring such as may wish for a more distinct idea of his practice, to the 12th volume of the *Repertory of Arts;* where it is fully described, and illustrated with an engraving.

SMELTING OF ORE. See Ore.

SMOKE, a fume or vapour, disengaged in the act of combustion. The curing of smoky chimneys, or fire places, or the method of preventing the smoke from passing downwards, may be seen in the article on Fire Places.

If the funnel of a chimney, says Dr. Willich be too short, (which is necessarily the case in low building, as it would otherwise endanger the roof,) it will be advisable to contract the opening of the chimney, so as to compel the incumbent air to pass through, or at least very near to the fire. Thus, the funnel will become warmed: and the confined air being rarefied by heat, will rise upwards, and maintain a proper draught at the orifice.

Another cause of chimnies smoking, arises from the injudicious position of a door. Hence, if the door and chimney happen to be on the same side of the room, and the former should open against the wall, the air will necessarily pass into the chimney, and expel the smoke into the room. This inconvenience will be felt particularly, on shutting the door; the current being then considerably increased, to the great annoyance of those who may be near the fire. Such nuisance may be easily prevented, by placing a screen from the wall round the fire place, so as to intercept the air. A more simple method, however, is that of changing the hinges of the door, so that it may open the contrary way; and thus occasion a current of air to circulate along the opposite wall.

Lastly, the chimnies of new houses, for want of sufficient ventillation, frequently smoke to such a degree, as to render them almost uninhabitable. To remedy this unpleasant molestation, it has been proposed to draw down, the upper sash of a window, for the space of an inch. As the frames, however, are generally fixed, especially in old houses, an expedient has been adopted, of cutting a circular hole, in a pane of glass, and substituting a round plate of tin, suspended on an axis, and divided into vanes; which, being severally bent in an oblique direction, are moved by the current of air; and the ventilator is forced round, in a manner similar to the sails of a windmill. This contrivance generally answers the end proposed; but, as the continual noise is very troublesome, the following method has been preferably devised. It simply consists in taking out a pane of glass, and suspending it on hinges, so as to be opened and shut at pleasure; or the pane may be set in a tin frame, and supported by two moveable joints on each side, serving the purpose of letting it down or drawing up and shutting it, according to circumstances, having proper hinges at the lower part: thus, by opening such a pane, to a greater or less distance, the necessary supply of fresh air may be admitted, without exposing persons in the room, to the draught.

SMOKING, in domestic economy, is a mode of preserving meat, such as hams, bacon, geese, &c. by previously salting, and then exposing them to the smoke, arising from a wood fire.

A fire from the branches of the juniper-tree, imparts to the flesh of animals a very agreeable, pungent flavour.

Smoking of Lamps.

Is a circumstance frequently diregarded, in domestic life. Let a sponge, three or four inches in diameter, be moistened with pure water, and in that state be suspended by a string or wire, exactly over the flame of the lamp, at the distance of a few inches: this substance will absorb all the smoke, emitted during the evening, or night; when it should be rinced in warm water, and thus again rendered fit for use.

SNUFF, a well known preparation of tobacco, with sundry odoriferous or other matters, occasionally added. The tobacco is reduced to powder, and the other articles are afterwards mixed with it.

It will be sufficient to say, that there are three classes of snuffs, under which all the rest may be placed, viz. 1. Gra-

nulated. 2. An impalpable powder. 3. The bran, or coarse parts, remaining after the second sort has been sifted.

Lord Stanhope has made a calculation, of the time wasted by professed snuff-takers, which, as it is both curious and amusing, shall be here inserted.

"Every professed, inveterate, and incurable snuff-taker, (says his lordship,) at a moderate computation, takes one pinch in ten minutes. Every pinch, with the agreeable ceremony, of blowing and wiping the nose, and other incidental circumstances, consumes a minute and a half. One minute and a half out of every ten, allowing sixteen hours to a snuff-taking day, amounts to two hours and twenty-four minutes, out of every natural day; or one day out of every ten. One day out of every ten, amounts to thirty-six days and a half, within the year.—Hence if we suppose the practice, to be persisted in forty years, two entire years of the snuff-taker's life, will be dedicated to tickling his nose, and two more to blowing it. The expense of snuff, snuff-boxes, and handkerchiefs are not here insisted on, though they would make a separate essay by themselves: in which it might be made to appear, that this luxury, encroaches as much on the income of the snuff-taker, as it does on his time; and that by a proper application, of the time and money thus lost to the public, a fund might be constituted for the discharge of the national debt."

Whimsical, however, as the above observations undoubtedly are, yet it may be ascertained, that the snuff-taker, is by no means a useless member of society; for, if the consumption of tobacco be duly estimated, and the wear and tear of apparel be added to the accompt, something is rather gained than lost by the public. Nor will the individual snuff-taker be injured; as his lordship assumes a term of forty years, to his reckoning, as if life were prolonged by the operation.

How to perfume Snuff with Flowers.

The tube-rose, the jessamine, the orange-flower, are those which communicate the more easily their fragrancy to the snuff. To produce this, have a box lined with white paper, perfectly dry, in which make a bed of snuff, of the thickness of an inch; then one of flowers, another of snuff, and another of flowers again; continuing so to do, till you have employed all the snuff. After having let this stratification subsist for twenty-four hours, separate the flowers from the snuff, by means of the sieve, and renew the same stratification again, as before, with new flowers. Continue this, till you find that your snuff has acquired a sufficient fragrancy from the flowers: then put it into lead boxes, to keep.

Another Way to do the same.

There are people who make the stratification another way. They inclose their flowers between the sheets of white paper, filled with pin-holes as thick as possible; this bed they lay between two of snuff; and, as for the small quantity, which may have got in the papers through these holes, you sift it out by means of a sheer, horse-hair sieve. The flowers must be renewed four or five times. This method seems the less troublesome; and the snuff catches the odour nearly as well.

Another Method.

A preparation of snuff may be made of an excessive nice fragrancy, with buds of roses. The process is this. Rob those buds of their green cup, and the pistillum which is in the middle; instead of which last, you are skilfully to introduce a clove, without damaging, and breaking, or loosening the rose-leaves, which are closely wrapped up one in another. Such buds, thus prepared, put into a glass vessel well covered over with a bladder, and a leather besides, and expose them for a month in the sun; after which term, you make use of these buds as before directed, for the other flowers.

Snuff of Mille-fleur.

This *mille-fleur* snuff, or snuff of a thousand flowers, is made by mixing together, a number of odorous flowers, managing the quantity of each of them, according to the greater or less degree of fragrancy, they are empowered with, so that none be found to have a predominancy over the others. When that is executed, you proceed, as before directed, to the alternate stratification of this mixture, and of the snuff-powder.

Snuff, after the Method practised at Rome.

Take the snuff after being perfumed with flowers, and put it into a large bowl, or other proper vessel. Pour over it some white wine, with an addition, if you choose, of essences of musk and amber, or any other such like odours. Then stir your snuff, and rub it between your hands. In this manner, you may have snuff of whatever you desire, which, to distinguish from each other, you put into seperate lead boxes, with a particular mark.

The Snuff with the Odour of Civet.

Take a little civet in your hand with a little snuff; spread that civet, more and more, by bruising it with your fingers, and an addition of snuff. After having mixed and re-mixed it thus in your hand, with the whole quantity of snuff, put all again together in the box as before. You may do the same with respect to other odours.

Amber-snuff.

Pound in a mortar, twenty grains of amber, adding by degrees one pound of snuff to it, which you handle, rub, and mix afterwards with your hands, to introduce the odour the better among it.

Snuff, Malthese fashion.

Take a snuff ready prepared with orange flower-water, then perfume it with amber, as we have just said; after which, with ten grains of civet, which pound with a little sugar in a mortar, you introduce again your snuff by degrees, to the quantity of one pound for these ten grains, increasing either the snuff or the odours, in the same proportion to each other.

The true Malthese Method of preparing Snuff.

Take rose-tree and liquorice roots, which you peel. Reduce them into powder and sift it; then give it what odour you like, adding white wine, brandy or spirit of wine, and mix your snuff well with this. Such is the true Malthese method of preparing snuff.

The Spanish method of preparing perfumed Snuff.

1. Pound in a small mortar, twenty grains of musk, with a little sugar. Add by degrees as much as one pound of snuff to it: then pound ten grains of civet, and introduce your pound of musked snuff to it, in a gradual manner, as you did before, and rub all together between your hands.

2. The Seville-snuff is the same with only an addition of twenty grains of vanilla, an ingredient which enters into the composition of chocolate.

3. They who are fond of a milder and sweeter odour in their snuff, may increase the quantity of snuff for the prescribed doses of odours, or diminish the doses of odours prescribed for the quantity of snuff. You must take great care not to let odorous snuff be uncovered in the air, but to keep it very close, for fear it should lose its fragrancy.

4. As the Spanish snuff is excessively fine, and drawing towards a reddish hue, to imitate it in the above prescription, you must choose fine Holland, well purged, reddened, and granulated; pound and sift it through a very fine silk sieve. Then you give it whatever odour you like, after having purged it in the manner we prescribed in this chapter, art. 2.

5. There is no inconveniency in taking a snuff already prepared with flowers, to give it afterwards, when you like, an odour, of musk, amber, or other perfume. On the contrary, such a snuff is the readier to take the other odours, and preserve them so much the longer.

SNOW.---The effect of snow in fertilizing soils has long been an acknowledged fact, but the cause of this property has been disputed; and it is perhaps still to be regretted, that it has never yet been sufficiently examined by chemical analysis. Hassenfratz has lately asserted, that it contains a large quantity of air, and that this air has a large proportion of oxigen. His proofs are, that infusion of litmus dropped into snow-water gives it a redder tinge than it does distilled water; and that much more oxide of iron is precipitated by it from a solution of the sulphat. Dr. Carradori, however, observes, that fish soon die in snow-water, which he ascribes to its want of oxigen: and that it does not give out oxigen gas, when exposed to the action of light.

SOAP, is a saline compound, formed from fat or inflammable bodies, which, not being soluble in water by themselves, compose, by the assistance of salts, a homogeneous mass soluble in water. These substances are slippery to the touch, soluble in water and alcohol, and commonly lather and froth with these fluids, upon being agitated with them; they also render several other substances miscible with water. They are discriminated from each other, not only by the various salts, but likewise by the different sorts of fat substances employed in their preparation. Similar combinations also are found ready formed in nature, though these are less in use and require to be adapted by art to the different purposes to which they may be applied.

Different vegetables very evidently exhibit by nature a saponaceous quality in their composition, of which soap-wort, the soap-berry tree (sapindus saponaria) and the common nightshade, may be adduced as instances. Now since the period that we have been convinced of the presence of alkaline salts in vegetables, nothing is easier than to conceive the origin of a mixture of this kind. In proportion, therefore, as this salt and the oily parts exceed the rest in quantity, and the force of the alkali is not weakened at the same time by the presence of an acid,

such vegetable will be more or less of a saponaceous nature. Sometimes also, though more rarely, a saponaceous compound is met with in vegetables, which consists of oleaginous particles and an acid. For this reason it is necessary in every case, previous to attempting to ascertain the composition of one of these compounds, to see of what kind it is. With this view, the watery extract of the saponaceous plant needs only to be mixed with a solution of fixed alkaline salt, and notice taken, whether any precipitation or separation of the constituent parts ensue or not. If in this operation the mixture be not observed to become turbid, but that an acid, on being added to it, produces this effect, it may reasonably be inferred, that this saponaceous compound has an alkaline salt for its basis. But if upon the addition of an acid to such extract no alteration ensues, and it is, on the contrary, rendered turbid by an alkali, it may be concluded, that the composition is saponaceous with an acid basis.

A perfect soap cannot be produced by art with acids. From the commixture of fluid acids and oily substances no other than greasy, saponaceous masses are produced; which, though they are miscible with water, cannot be brought into a solid and concrete state, and at the same time preserve their saponaceous qualities.

The alkaline salts, on the contrary, are intermediate substances, by which all oleaginous or other inflammable bodies may be brought into a perfectly saponaceous state. But in order to promote the combination proposed, they must necessarily be deprived of carbonic acid, by boiling with quicklime.

We shall first mention some of the substances used in the art, and the articles from which some of them are obtained.

Barilla, or *barillia*, the name of a plant cultivated in Spain for its ashes, from which the purest kinds of alkali are obtained.

There are four plants which, in the early part of their growth, bear so strong a resemblance to each other, as would deceive any but the farmers and nice observers. These four are, *barilla*, *gazul*, (or, as some call it, *algazul*) *soza*, and *salicornia*, or *salicor*. They are all burnt to ashes, but applied to different uses, as being possessed of different qualities.

Gazul bears the greatest affinity to barilla, both in quality and appearance. The principal difference consists in its growing on a still dryer, salter earth, consequently it is impregnated with a stronger salt.

Soza, when of the same size, has the same appearance as gazul, but in time grows much larger, as its natural soil is a strong salt marsh, where it is to be found in large tufts of sprigs, treble the size of barilla, and of a bright green colour, which it retains to the last.

Salicor has a stalk of a deep green colour, inclining to red, which last becomes by degrees the colour of the whole plant.

Barilla affords less salt than the others. When burnt, it runs into a mass resembling a spongy stone, with a faint cast of blue.

Gazul, after burning, comes as near barilla in its outward appearance, as it does when growing in its vegetable form; but, if broken, the inside is of a deeper and more glossy blue. Soza and Salicor are darker, and almost black within, of a heavier consistence, and very little or no sign of sponginess.

All these ashes contain a strong alkali, but barilla the best and purest, though not in the greatest quantity. Upon this principle, it is fittest for making glass, and bleaching linen. The others are used in making soap.

The method used in making barilla is the same as that of burning kelp.

The plant, as soon as ripe, is plucked up, and laid in heaps, then set on fire; the salt juices run out below into a hole made in the ground, where they collect into a vitrified lump, which is left about a fortnight to cool. An acre may give about a ton.

American Pot-ash,

Is a fixed vegetable alkali, another valuable material in hard soap-making, prepared from the ashes of burnt wood in America, Russia, &c. For the process of preparation, see Potash.

Having mentioned a few of the principal and the best ashes used in the manufacturing of hard soap, we shall turn our attention to the mode used for detecting sand therein.

This fraud is but too frequently practised, not only by kelp-burners, but barilla-makers also; that is, mixing sand with their commodity while manufacturing, and in a liquid state.

The process used for detecting sand is simple, and not tedious, viz. take two ounces of a fair sample from any parcel meant to be purchased; beat it down in a mortar very small, pour some boiling water upon it, and rub it well in the mortar; pour off this, and add more, and so continue until all the black light substance is gone off with the water. The sand will then be found in the bottom of the mortar, and, if surveyed with a magnifier, will resemble in appearance small pebble

stones, or channel, of various colours. Dry and weigh the sand; and from the quantity contained in the two ounces, a calculation may be made for the hundred weight or ton.

A certain given quantity of water ought always to be allotted for trying this experiment; say, one or two pints: and by weighing one pint thereof afterwards, when the experiment is finished, the quantity of alkaline salt may also be discovered which one pint of said ley contains; thus, an English pint of spring water weighs 15 oz. 3 drs. 12 gr.—so that all above that weight in the rubbing water, or ley, must be supposed alkaline salt. The price of the article ought to be regulated according as the experiment turns out.

From the ashes already mentioned, the strongest and purest vegetable alkali is obtained From other vegetables, as fern, broom, bean-stalks, &c. an alkaline salt is produced, but so impure, and in such small quantities, that no soap-manufacturer can use them with any reasonable expectation of profit.

The other ashes, in the language of the soap-boiler, are the following:

Blue Pearl-ashes.

Half a pound of these will give about 5½ ounces of pure potash;

White Pearl-ashes,

Are nearly of the same quality with the former, half a pound of them giving five ounces and seven drams of pure alkali;

Russia, or Muscovy ashes,

Have very much the appearance of slacked lime, and are, like it, friable, or may be powdered or crumbled betwixt the fingers. Half a pound of them will only give about ten drams and fifteen grains of a very caustic salt. These consist, therefore, of a small quantity of alkaline salt, united with a large quantity of lime.

Cashul ashes,

Are of the colour of iron, and extremely hard, with many shining particles of charcoal in them. They have a saline taste, with a considerable degree of pungency. Half a pound of these ashes being boiled in a quantity of water for twenty-four hours, and evaporated, produced only ten drams of a brown salt, having a strong caustic alkaline taste.

Marcoft ashes,

Are of a paler colour than the former. Half a pound of them dissolved in water, filtrated and evaporated, yielded only eleven drams one scruple and two grains of alkaline residuum.

A boil with these pearl-ashes, after the rosin has been melted, is peculiarly serviceable for killing the tallow, (according to the common phrase); it converts the whole mass in the pan to a consistence, or thin weak soap But this will be better understood when we come to the operation of boiling or making the soap; a process which we shall immediately set about.

Let us now suppose that every thing is ready for commencing the operation upon a moderate scale, viz. that there is a small soap-pan, capable of casting from 20 to 24 cwt. of soap, six or eight iron vats, or caves, with receivers that will contain 12 or 14 cwt. of kelp or ashes, each; that there is also kelp, ashes, tallow, lime-shells, and palm oil, at hand. These are all the materials necessary for performing the operation, and finishing a pan, or making of hard soap.

The first thing to be done is, to prepare for setting a cave, viz. Break down very small about 12 cwt. of kelp, and, to make a good ley, 2 or 3 cwt of American potash may also be broke and mixed therewith. Barilla ash is generally set by itself alone. The breaking, however, of the American potash, from the danger of sparks (if great care is not taken) of flying into the eyes, or lodging about the feet, &c. would be as well altered to melting down, or dissolving in boiling water, and then poured upon the other materials (just now to be mentioned), after they are put into the cave.

The kelp now broke, spread about one-sixth part of it upon the floor, or slake-pit, if there is one, upon which lay about half a bushel of lime, and water it. When it begins to burst and crack, put on another layer of kelp, then more lime, and water them; and so on, stratum *super* stratum, or one above the other, until there is about the quantity of 2½ or 3 ash barrels of lime mixed with 12 cwt. of kelp. Let this stand for the space of two hours. The cave in the interim may be got ready for receiving them, thus: Lay two rows of bricks upon the bottom, from the hole or pipe quite across to the opposite side, forming therewith a small channel, of three or four inches breadth. Cover this over with any convenient thing, such as slate, tyle, a piece of dale, &c. And to crown the whole, lay on some straw, or an old bass mat, &c This is to prevent the grosser part of the materials from getting in and stopping up the channel, intended only for the leys to run in. Stop up the pipe, or hole in the cave, with a

pin, about which ought to be lapped a piece of paper to keep all close.

The preparations now accomplished, we proceed to what is generally termed,

Setting a Cave.

The principal object here to be observed, is to mix the compound well together, previous to putting into the cave. The first bucket or two should be very gently laid upon the covered drain, or bottom of the cave. This will secure the straw, or mat, from being disturbed afterwards, by throwing in the rest of the materials.

Throw on two or three pails of water, at different periods, during the setting, which will have the effect to dissolve any small particles of lime that may formerly have escaped the water. Observe always to leave a vacancy at the top of the cave, of about eight or ten inches at least, in order to give room for swelling of the lime, and filling up with water.

Supposing now the kelp and lime all put into the cave, and no ash therewith, but that these ashes have been melted down, or dissolved in boiling water, and are converted into ley; pour that upon the top of the other materials, just put into the cave, and fill up with water, until the whole is completely saturated therewith; the completion of which will be evident, when the bubbling in the cave ceases to arise. Let the whole now stand for 12 or 14 hours, adding, however, a little more water as the stuff appears to dry up, or absorb that already put on. When the cave has stood the above time, loose the pin, and let the ley run briskly off. When all is off, stop up again, and fill with water, which may stand the half of the former time; the pin may again be loosed, and the leys allowed to run gently off, keeping the cave always filled up or supplied with water. It may be unnecessary here to remark, that we must hitherto be supposed, as laying down directions to a person just going to commence soap-making, but perfectly ignorant of the operation, and that he is preparing every necessary agreeably thereto In that case, descending to particulars will, we hope, be excused by the knowing, or more experienced reader.

We shall now go on by informing, that before beginning to boil, more leys must be got ready; consequently, another cave may be prepared in the same manner as the former one; with this exception only, that instead of filling up, or supplying the second cave with pure water, let it run through the former cave first, and then put upon the second The intention of this is obvious; that, while the last is supplied with water, the remaining strength of the first is extracted, and collected into the second: and this must be the uniform practice at all times, that none of the alkali be lost; never turning out a cave, as spent, until you discover by the test, the alkali is vanished.

Having just mentioned the test, we shall take this opportunity of explaining what it is.

It is prepared in the following manner: Take a parcel of the blue flowers of any vegetables, violets, for instance, or the blossom of the mallow; beat them with the edge of a knife, and squeeze the juice of it into a tea-cup; with a small brush, or hair pencil, lay over a sheet of white paper with this juice, and when dry it is fit for use. All alkalis will turn it green, and all acids will turn it of a red colour. A combination of them both, to the point of saturation, will not in the smallest degree alter the colour of the test, because they are then said to be neutral, having neither the properties of an acid, or an alkali: but add a few drops more, of either the one or the other, the effect will be evident. If alkali is added, the test will be green; if acid, it will be red.

An intimate acquaintance with every particular relative to the leys, is the one thing needful for a soap-boiler, being as it were the ground-work of the whole operation, and materially essential to be well understood, before any attempt ought to be made at soap-making

We come now, of course, to examine the leys already prepared, and to determine by experiment, whether they are, or are not, fit for soap-making; that is, whether they are caustic and fit, or in a mild state, consequently unfit for the purpose.

Unless a soap-ley be rendered caustic, or deprived of its fixed air, it can have no union with vegetable or animal substances, such as oil, tallow or grease of any kind, so as to convert them into a soap. For the sole purpose, therefore, of extracting the fixed air from the leys, do soap-makers use quicklime Depriving the mild alkali of its fixed air, renders it caustic, or of a burning, corroding quality, and of that peculiar nature, that instantly attach themselves to all greasy substances, and converts them into a soap.

The common vulgar notion, of using quicklime for its heat, is a mistaken idea, although we know it to be entertained by many soap-makers.

A mild ley, or that possessing fixed air, can have no effect upon vegetable or animal substances, so as to convert them into a soap.

Hence we may perceive the pernicious practices of some soap-boilers, namely, melting down, or dissolving potash in boiling water, and in that mild and improper state, adding those leys to the boiler.

Such consummate ignorance persevered in, must, and always have proved ultimate ruin to the person himself, or his unfortunate employer.

To determine, therefore the proper state of the ley, take a quantity in a glass, or tea-cup, drop therein a few drops of sulphuric acid, or oil of vitriol; if this causes an effervescence, or seeming fermentation in the ley, the fixed air is not fully extracted; but if no such appearance ensue upon the combination of the acid and alkali, the ley is fit for immediate use, being arrived at the state of a proper caustic soap-ley.

A soap-ley, by being long exposed in open vessels, will lose the whole of its causticity, and seem entirely restored to the state of an ordinary fixed alkali. The keeping them as close as possible, therefore, appears exceedingly necessary.

By means of the acid, may be discovered also the comparative strength, between one ley and another, and so ascertain, which of the two contains the greatest quantity of fixed alkaline salt. Thus, take a specific quantity of each; a wine glassful, for instance; drop therein a dozen drops, or so, of acid; stir with a bit of stick, and apply a slip of the test-paper. If it appear green, more acid must be added, and stirred again. Applying the test a second time, if still green, a few more drops must be added; and so continue, until you find the paper is by no means altered in the colour, neither green nor red. The ley is then neither an acid nor an alkali, but neutral, or a combination of both, brought to the point of saturation. A few drops more of the acid, would occasion the test-paper to take a red, instead of a green colour, which would distinctly show the power of the acid to prevail.

Treating in this manner the different leys, then counting the number of drops taken to neutralize them, the strongest ley will be discovered to be that which has required the greatest quantity of acid, to overcome the power of the alkali.

Soap leys are also judged of by their specific gravity, or weight, comparative to water.

	oz.	*dr.*	*gr.*
An English pint of spring water weighs about . . .	15	3	12
A strong soap-ley, the English pint weighs about . .	17	6	24
The diff. between the two is,	2	3	12

—and supposed to be the quantity of fixed alkaline salt, contained in one pint of such ley.

A most accurate and easy method for ascertaining the strength of soap-leys for immediate use, is as follows, viz.

Take a small bottle, and having filled it with water, put it into one scale, and as many lead-shot into the other, as will exactly balance it. Suppose 128 is requisite for that purpose. Suppose, again, that the bottle and water just weighs four ounces; this is throwing it into 128 parts; half of that is 64-128, or 2 ounces; halve it again, is 32-128 parts, or one ounce; again, is 16-128 parts, or 8 drachms; then into 8-128 parts, or 4 drachms; 4-128 parts, or 2 drachms; 2-128 parts, or one drachm; and 1-128 parts, or half a drachm, which is bringing it to the lowest denomination.

Get proper weights made for each of these divisions; and when the strength of the ley at any time is required to be ascertained, fill the bottle and put it into the scale: into the opposite one, the balance of water, or the 128 shot, is placed; and as ley is always heavier than water, some one or other of the divisions will be wanted to balance the ley: therefore, whatever division may answer for that purpose, must be called the weight of the leys; the surplus weight above that of water being only reckoned, and not the whole quantity: For instance, if the bottle of ley take the division weight No.16, in that case the ley is 16-128 parts heavier than water, or 8 drachms, reasonably supposed to be alkaline salt.

Having endeavoured to furnish the reader, with a tolerable idea of the preliminaries of soap-making, we shall now proceed to what we consider the easiest and most simple part of the business, the boiling; although by the ignorant and unwary, conceived to be the principal requisite, and containing the whole mystery of the trade.

The leys being now ready, we shall commence with a boiling of brown or yellow soap. For this purpose, let there be weighed 10 cwt. of tallow, and about 3 cwt. of rosin: the rosin to be broke in small lumps. In the first place, put into the boiler about 150 or 200 gallons of leys (about the weight of 16 oz. 4 dr. 48 gr. the English pint, which will nearly answer to No. 32, of the fore-mentioned divisions,) and set the fire; then add the tallow and rosin. This done, the pan is said to be charged.

A good fire may be kept up until all is thoroughly melted, and the pan brought to boil; during which time there ought

to be constant stirring with the paddle, to prevent the rosin settling to the bottom. If the goods or materials in the pan appear to swell up, damp the fire, which is done by opening the furnace door, and throwing ashes thereon, (some have proper dampers,) when the whole will boil at leisure. As the caustic alkali immediately grips to the tallow, there is no occasion for long boiling; about two or three hours will be long enough: the fire may then be drawn, and the pan allowed to stand four or six hours, when the weak leys may be pumped off, and fresh ones added for a second boil. It may be necessary to mention, that when the pan is wished to be cranned, or pumped off sooner, a few pails of cold ley must be thrown in, a little after the fire is drawn.

Set the fire again for second boil, and when properly a-boil, two or three hours may be sufficient at any one time to continue the boil: the strength of the leys are often gone before that period arrives. A short experience, however, with attention, will perfectly inform any sagacious person with regard to this particular.

The boilings to be thus continued day after day, until the soap becomes thick, and of a strong consistence. Take then a little upon the forefinger, and after letting it cool a few seconds, press it with the thumb. If it squeezes into a thin, hard scale, the soap is fit, or ready for finishing: if otherwise it appears greasy, and sticks to the finger, and of a soft consistence, more leys must be added, and if that does not harden it, another boil must be given. But, in consequence of the former scaly-like appearance, give the pan a good hearty boil, and draw the fire. Cool down with two or three pails of leys, and in about two hours thereafter pump off the leys; which should be done at all times as clean as possible. This done, put in six or eight pails of water to the boiler (no leys at finishing being used,) set a brisk fire, and keep constantly stirring with an hand-stirrer and paddle alternately, until all is melted, and begin to shew an appearance something like thin honey Take now a little from a boiling part, upon the hand-board, and observe, when held up, if any leys run clearly from it: if they do, more water must be put in, and the boil continued, &c. If it be wished of a beautiful colour, 20 lbs. of palm oil may be put into the boiler.

It is not essential to employ heat in producing a good soap, for the union between the oil and alkali will be perfect by a sufficient length of time of digestion, if the ley be strong enough. Thus a very pure soap is sometimes made for medicinal purposes in the following way: mix in a marble mortar, or any vessel not metallic, any quantity of olive oil with half its weight of a strong ley of caustic soda. The oil should be previously melted in case it has become clotted by age. Stir them well together, and they will immediately unite into a thick white mass, and continue the stirring for some minutes several times a day for about a week, or till the soap is stiff enough to be put into wooden frames in the usual way. Let it remain in the frames for three or four days, till it has considerably hardened, and then cut it in slices, and expose it to a free current of air in a dry room, till it is complete. This soap has at first a very strong lixivial smell, and a violently acrid taste, both of which go off by exposure to the air, but it takes nearly a month before the taste is mild or merely saponaceous

Before we describe the manufacture of the other kinds of soap, we may give in a few words the results of a series of valuable, and apparently accurate, comparative experiments on the soaps made with soda and a variety of oily substances, which were undertaken by Pelletier and his colleagues. The quantity of the oily substance in each instance was 3 lbs. and the method pursued was nearly that which has been described as followed in the large way.

Olive Oil.

Three lbs. (avoirdupois) of this oil produced 5 lbs. of pure white soap in that state of dryness as to be fit for sale. After keeping for two months, it lost an ounce more in weight, and was then quite dry, hard, and of an agreeable smell.

Oil of Almonds.

Three lbs. of this oil gave an excellent soap in every respect equal to the former, but after two months weighing only 4½ lbs.

Suet.

The animal fats are much less used in France for soap-making than in England, but the soap which they give is in every respect as good as that from olive oil. The precaution used in oil soap-making of employing the weaker ley at first, and gradually proceeding to the stronger, was not found necessary in this case. Three lbs. of suet gave 5 lbs. of perfectly hard soap, after keeping three months and a half in a dry place.

Lard.

Three lbs. of lard gave 4 lbs. 14 oz. of dry hard soap, after keeping for three months. In this and the former experiment, the spent ley which separated from

the soap, contained a quantity of animal gelatine.

Rancid Butter.

A quantity of stale salt butter was boiled with water to extract the salt, after which 3 lbs. of it were weighed out and treated with soda in the usual manner. From the above quantity a white soap was obtained with ease, which the day after it was made weighed 11 lbs. and still retained some of the bad smell of the butter, and on keeping for two months it still weighed 7 lbs.

Horse Oil.

A good deal of grease is prepared near Paris from horse flesh, by boiling. Of this, 3 lbs. gave 5 lbs. of good hard soap without any unpleasant smell, after keeping for two months.

Coleseed Oil.

Coleseed, hempseed, linseed, rape, and many other common vegetable oils, have a strong unpleasant smell and taste, so as not to be used in food, but they are employed largely in the state of oil for several purposes of manufacture. In general they are not much used for the *hard* soaps with soda, but a good deal of soft soap is made of them in Flanders and Holland, with pearl-ashes, as will be presently mentioned. In the above experiments they gave the following results:

Three lbs. of coleseed oil, treated as above, with soda, gave, on coming out of the frame, only 5 lbs. of soap, which was yellowish gray, and still smelled strongly of the oil. On keeping for three months, it was reduced to 3 lbs. 12 oz. and was tolerably hard, but by no means equal in this respect to olive oil, kept the same length of time.

Rape Oil.

Three pounds of this oil gave also a yellowish gray soap, which after keeping for three months, gave 4½ lbs. of a good soap, sufficiently hard.

Beech-Mast Oil.

Three pounds of this oil gave a gray strong smelling soap, which, after three months, weighed 4 lbs. 10 oz., and was still pasty, and stuck to the fingers. This oil, therefore, can only be used in mixture with others that give a harder soap.

Hemp-seed Oil.

This is one of the most valued oils for the soft soaps, but will not answer for the hard. Three pounds gave, after due boiling, a green soft saponaceous mass, which became pasty on any addition of water. After two months it weighed 4½ lbs., and hardened a little, but not sufficiently to be used in common washing.

Linseed Oil.

Three pounds of this gave 5 lbs. of soap on coming out of the frames, which was greasy, pasty, and adhesive, with a very strong smell, and softened speedily on any addition of water. In two months it lost half a pound of its weight, but remained pasty and adhesive.

Whale Oil.

This, and other kinds of fish oil, unites sufficiently well with soda, and forms a deep red-brown soap of tolerably hard consistence; but this soap has the inconveniences of long retaining the offensive smell of the oil, and being too readily softened by water, which unfit it for domestic purposes, though it may be used in bleacheries, &c. where the smell may be dissipated by long exposure to the air. Three pounds of this oil gave 4½ lbs. of soap, after keeping for two months. Ling and seal oil soap have nearly the same properties and inconveniences.

All the above experiments were repeated with the crystallized carbonat of soda, instead of the barilla of commerce, which was employed in the first set of experiments, and the respective results so nearly agreed with the former, that a particular enumeration of them is needless. In these latter 3 lbs. of carbonat of soda, rendered caustic by 1 lb. of lime, were used for 3 lbs. of the oil; but in manufacturing in the large way, the experimenters conceive that 80 parts of the alkali would be sufficient for 100 of the oil.

With the fixed alkaline salts, soda as well as pot-ash, tallow-soaps are prepared in the following manner: One part of either of these alkaline salts, and about two parts of quick-lime, as much as is requisite to render them perfectly pure, are to be mixed together, and made into a strong ley, with the necessary quantity of water. This ley is then made to boil with three parts of tallow or fat over a gentle fire, and kept continually stirring till the mixture becomes thick, and ceases to adhere to the hand, when a little is taken out of it for a sample. Toward the end, a proportional quantity of common salt is added, by which the soap acquires a greater degree of hardness. This effect has been accounted for on various suppositions. It has been said, that the quantity of water present is diminished by the abstraction of as much as the salt requires for its solution; a circumstance probably of little consequence. Again,

the soap is rendered less soluble in the water by this addition; and therefore more readily separates. But the most important effect seems to be, that the muriatic acid of the salt attracts the potash of the soap, and gives its own soda in return, which is known to afford a much harder soap. The weight of the soap here acquired is commonly, as Wiegleb says, double that of the tallow employed in making it. In the same manner a wax soap may be prepared either of yellow or white wax, which is about three times the weight of the wax, is very hard and firm, and has an agreeable smell of almonds. The Gravenhorts in Brunswick likewise prepare a soap of cocoa butter for medical uses Spermaceti also may be made into soap with a caustic lixivium.

Macquer gives us the following process for oil soap: One part of quicklime and two parts of good Spanish soda are boiled together during a short time, with twelve times as much water, in an iron cauldron. This lixivium is to be filtered, and evaporated by heat, till a phial, which is capable of containing an ounce of water, shall contain an ounce and three eighths of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of sweet almonds, in a glass or stone-ware vessel. The mixture is to be stirred from time to time with an iron spatula, or with a pestle, and it soon becomes thick and white. The combination is gradually completed, and in seven or eight days a very white and firm soap is obtained.

For the coarser sorts of soap cheaper oils are employed, such as oil of nuts, linseed, hempseed, fish, &c. Either of these kinds of soap, to be good, must neither feel greasy or unctuous in water, nor exhibit any vestige of fat upon the water. It ought farther to dissolve easily in water, and lather well, as likewise be easily soluble in alcohol. It must not become moist in the air, or throw out a saline efflorescence on its external surface.

The following methods of making different kinds of soap are given as specimens of those in actual use, in a treatise on soap-making, by a manufacturer, lately printed at Edinburgh, to which we have been indebted for sundry observations.

A Charge for pure White Soap.

The boiler being made perfectly clean, put in 10 cwt. of best home melted tallow (no resin is used in white soap) with 200 gallons of ley; melt down with a moderate fire, as the goods now in hand are something similar to milk, exceedingly apt to boil over.

Close attention, therefore, is absolutely needful upon this first boil; which may be continued about two hours, with a moderate fire, when it may be drawn away, and the pan allowed to settle about two hours, when the ley may be drawn off. The process to be observed in this soap is exactly similar to the last operation. Two or three boils a day to white soap may be given with great ease; the ley sooner subsiding in the boiler than with yellow soap, and can be cleaner pumped off.

When sufficient boils have been given, and the soap is arrived at perfection, it will assume an appearance something like a curdy mass. Take then a little upon your forefinger (as before directed); and if the same effect seem to attend it, that is, when pressed with the thumb it sqeeze into a thin, hard, clear scale, and part freely from the finger, the soap is ready for finishing. Draw the fire cool down with a few pails of ley, and in a short time thereafter pump clean off.

Set the fire, and add to the soap eight or ten pails of water (the pail we suppose to contain about nine or ten English gallons). When this is melted, and properly incorporated with the soap, try, as formerly directed, if the ley run from it when held up upon the hand-board. If it do, more water must be put in. If it do not run, or there be no appearance of it, continue boiling for a short time longer, and then add a pail of salt and water pretty strong, mixed together; about one third salt, and two thirds water This will have the effect of cutting up the pan, or separating the soap and water completely from one another. When this is apparent, draw the fire; let it stand for half an hour, when the water will pump off, bringing therewith most of the remaining alkaline ley of the former boil.

This I call the first washing; and if kelp ley has been used in the operation, the propriety of this must be conspicuous, for the water pumped off will be of an exceeding dark bottle green colour. The finishing of white soap without this precaution is the sole cause of the blueness, so frequently observed in this article when made and brought to market.

The blue ley being pumped clean off, set again the fire, and put into the boiler six or eight pails of water; and when thoroughly incorporated and boiled some time, try if the water run from the soap: if it do, add water in small quantities at a time, until it is observed not to run, but, as formerly mentioned for yellow soap, to appear as just starting from the soap; in this case, after giving a good boil, and

swelling the soap up in the pan to near the brim, draw away all the fire, and spread it about to die away. The pan is now finished, and may stand about twelve or fourteen hours; and if the quantity be large, that is, two, three, or four ton, double this time to stand will be much in favour of the soap, providing always, that it can be kept very close and warm in the boiler. If any blueness still appear, repeat the washing.

Before casting, we would recommend the frames to have a bottom and lining of coarse cloth, for white soap only. After all is cast into the frames, let it be well stirred, or crutched; and it is very proper, that it also be covered close up with old sheets, bass mats, &c. upon the top of the frame and soap, and allowed to cool gradually, and all together.

In about three or four days (supposing, as formerly, the dip 30 inches) the coverings and frames may be taken off, and the whole cut up into such size of bars as may best suit the customers.

To give this white soap the perfume of what is commonly called Windsor soap, a little of the essential oil of caraway seeds mixed with a small portion of alcohol may be incorporated with the soap when putting into the frame, stirring it in, by little at a time, so as to diffuse it throughout the whole mass.

For making Black or Green Soft Soap.

The peculiar method pursued in making this soap differs considerably from that of making hard soap. The hard has the whole of the ley totally extracted before finishing: soft soap, on the contrary, retains the whole of the ley used in the making; becoming, with the other materials employed, one compound body, called *soft soap*. A few examples will clearly explain the nature and practical means made use of, in producing this very useful soap.

We shall now commence an operation with a charge for what is called,

First Crown Soft Soap, 18 *Barrels.*

The quantity of ley requisite for the completion of this charge will be about 400 gallons; about one third of which must be put into the boiler previous to any of the other materials: afterward add, 2 cwt. 2 qrs. of tallow, 2 cwt. 2 qrs. of hogslard, and 70 gallons of olive oil. The ley herein to be used is supposed to be from Hungarian and English (Essex) ashes. The proportion is one of the English to eight of the Hungarian. The particular mode of proceeding is thus: After the ley is put in, add the tallow, and light the fire. When all the tallow is melted, put in the oil, and draw the fire a little afterward, and allow the pan to stand about two hours. Light again the fire, and add about 20 gallons more of the ley. After the pan begins to boil, add now and then a little more ley, for the purpose of preventing the soap from boiling over: and this adding of ley is to be continued, until the soap is supposed to be about half boiled; when it will be time to try, whether the soap have got too much or too little ley.

This trial is called *proving*, and is necessary to be done several times during the operation, and previous to the finishing. The method of performing it is this: Provide a piece of glazed Dutch delft, and also a clear clean knife: with the knife take up a piece of the soap from the pan, and if it turn whitish thereon, and fall from it in short pieces upon the delft, it is then to be concluded, that too much ley has been put in; to rectify which, a little more oil must be added. On the contrary, if the soap want ley, it will fall from the knife in long, ropy pieces; in consequence of which add some more ley. When, however, it happens to be brought to perfection, neither wanting more lie nor oil, but just in a right state; it will then be observed, when taken upon the knife, to stand the proper colour, not ropy, nor too white, but transparent. The fire may now be drawn, the soap being properly finished, and ought immediately to be cast into the barrels, firkins, &c.

Remember always, after the second time the fire is lighted, to keep the soap boiling briskly, till the pan is nearly ready, when it ought to boil slowly, until finishing, and ready to cast.

A Charge for Second Crown Soft Soap.

280 lbs. of tallow,
140 gallons of ley,
82 gallons of whale oil.

Put in 100 gallons of ley, with the tallow, and light the fire. When the tallow is melted, add the oil, and draw the fire. Let all stand for two hours. Again light the fire, and add 20 gallons of ley. With this the boiling is to be continued, until the soap is about half finished, when 10 gallons more of ley are to be added. During the remainder of the boiling, add, at different periods, the other 10 gallons of ley, which will completely finish the soap.

A Charge for best common Soft Soap, with Old Soap returned.

254 lbs tallow,
85 gallons train oil,
200 gallons leys, weight 11 drachms, blue pearl ashes.

At M. 6, charged with 140 gallons leys, and all the tallow, with 239 lbs. of old

soap. Set the fire. At 8, the oil put in, and fire drawn. At 10, the fire again lighted, and 40 gallons of leys added From this time till E. 2, at different times, add about 15 gallons leys. From this to 5, add at different periods, five gallons. At 6, the fire may be drawn, and shortly thereafter the soap may be cast into the firkins.

To know when the soap wants, or has got too much leys, observe the following directions. Take about the size of a pigeon-egg of the soap, while hot, and put it upon the delft. Observe if whitish streaks and specks plainly appear, and continues so after the soap grows pretty cold. When this happens, the soap has got enough of leys. If these appearances are not evident, in that event, the soap must have more leys. Or, to know if the soap have got enough of leys, dip the blade of the knife into the soap; and when coldish, stroak the soap off the knife upon your forefinger; observe if any streaks appear in the soap: if any, then the soap is plentifully supplied with leys; but if none, more leys must be added. It is always a good sign that soft soap is enough boiled, when, upon trial as above, with the soap on the finger, that it stands up, and appears with a thin roundish back; and when right, it will appear upon the finger of a greyish colour at the top of the outer edge.

When different leys are used, that is, some strong, and others weak, particular attention must be paid to the proportioning the one with the other, or, the weak with the strong, in order that a proper strength, or boiling ley, be had from the composition. If too weak leys are used, there is a danger incurred of spoiling the whole soap, which is hardly to be righted again.

To guard against this great evil, observe the following rule: Suppose there is three leys of different qualities to be boiled with, two of them is over weak, one is too strong; try their strength mixed together, thus:

		drachms.	*drachms.*
3 pails, or couls,	at 16 each,	is	48
3 ditto,	ditto, at 10 ditto,	is	30
3 ditto,	ditto, at 8 ditto,	is	24
9			102

9(102(11 3-9, or 1-3, { the standard for boiling ley.
9
———
12
9
———
3

We now find, that an equal proportion of these leys mixed together, produce, upon an average, a medium weight, equal to the standard for proper boiling ley. Weak leys take always a larger quantity, and much longer boiling. On the other hand, strong leys take a less quantity to do the same work, and considerable less boiling; consequently, in using a proper ley, both time and fuel is saved.

We shall here give an experiment made with great precision, to ascertain with regard to the expense attending the making of white soap The only materials used, of the alkali kind, was the second sort of potash, but of a quality very superior to what commonly is sold under that denomination.

"I broke down pretty small," says a manufacturer, "a quarter cwt. of American potash; and, with a proportionate quantity of good lime-shells mixed therewith, set them in a small yetlin cave. I added water just sufficient to saturate the mixture. In this state, having stood for about 12 or 14 hours, I let it run, and drew off 4 English gallons of ley, which I ascertained, by my hydrometer, to be 14½ strong. I filled up my cave with water, and continued the running slowly until I had 28 gallons more, of strength by hydrometer 18 strong. I then stopped up my cave from running, and proceeded to calculate the value of my ley, as follows:

In the first place, I find that 1-4 cwt. of American potash, at 55s. per cwt. (their real price at the time) is 13s. 9d. which must be the value also of my 32 gallons of leys, drawn from the ashes. At that rate, the English pint is worth about two farthings, and one half farthing. I now proceeded further to complete my experiment, and satisfy myself at what expense white soap could be made. For this purpose, I charged a small boiler, which holds about 1½ gallon, with 4 lbs. of good rhinded tallow, and with 10 pints of the ley of the weaker sort, or second running, which had been kept separate The pan boiled very close, that is, the leys and tallow became one mass of seemingly thin soap, without any appearance of separation betwixt the leys and tallow. In this state of the pan, I was obliged to add a little salt and water, which brought about a separation in a short time. I then let my pan stand off the fire for half an hour, when the weak leys cranned freely off. I now added six pints of same leys, for second boil. This had the effect totally to kill the tallow, and bring the soap to a pretty strong consistence, and the leys cranned off without salt in half an hour. I then prepared for third boil, by adding

7 pints more of same leys, 18 strong, and boiled half an hour. The soap appeared now strong, but rather close; and this closeness I attributed to too much salt; to rectify which, I added between one and two pints of water. This, in a short time, had the effect to bring on a separation. The pan was taken off the fire, and allowed to stand about an hour and a half, when it parted freely with all the leys. Nothing remained now to be done but finishing, which I completed with between 3 and 4 pints of water (some salt also was used,) in the course of an hour and a quarter The pan was now taken off the fire, and allowed to cool for 24 hours, when I found, upon weighing, I had 10½ pounds of good white soap. Upon looking over my jottings, taken during the operation, I found that there had been used about 23 pints of leys, and about 3 pounds of salt.

The expense of the whole will be evident by the following correct statement, viz.

	s.	d.
To tallow 4 lbs, at 7½*d. per* lb.	2	6
Leys, 23 pints, at 2½ farthings *per* pint - -	1	2¼
Salt, 3 lbs. at ½d. *per* lb.	0	1½
Duty charged on 10½ lb. soap, at 2¼*d. per* lb. say -	1	9
Fire, &c. about - -	0	2¼
Total expense -	5	9
By 10½ lbs. of soap, at 9d. *per* lb. (white soap was at that time selling in the shops at 10d.)	7	10½
Neat profit -	2	1½

A boiling of hard soap sometimes may misgive, or go wrong. It is then said to be a *spoiled pan.* In this state, much trouble and expense, to an inexperienced boiler, is the consequence, before such soap can be brought right. By attending, however, to the rules already laid down, such a circumstance will seldom happen.

Instances of what are called *spoiled pans* of soap, or soap, from inexperience in the course of making, converted into an uncommon mass, so as to baffle the utmost skill of the manufacturer to redeem, have frequently happened; though with the experienced and well informed soapmaker such disastrous failures will seldom or never occur, the causes to him being evident.

No soap ley at any time ought to be used, but such as by experiment is proved to be a caustic ley, entirely freed from its fixed air, and the soap will always be good.

The olive oil, Marseilles, and other soaps, are sometimes artificially *marbled,* or streaked throughout their whole substance with red or blue veins. This soap is harder than the white soap of the same materials, because it requires to be dried to a greater degree to take the marbling. This is performed by adding to the soap, as soon as it is completely made and separated from the spent ley, a fresh quantity of ley, and immediately after a solution of sulphat of iron. A decomposition between the two takes place, and a black oxyd of iron is separated which is entangled within the liquid soap. The boiler is then cooled, and the ley which settles is drawn off, after which the soap is again melted. A workman then stands over the boiler, and stirs the soap with a wooden instrument, whilst another throws in at intervals a quantity of colocothar, or brown red oxyd of iron, ground up with water into an uniform liquid. This diffuses both the oxyds through the soap, which is then cooled and framed. There appears to be some manual dexterity required in stirring these ingredients together, so as to diffuse the marbling sufficiently through the mass without mixing it completely.

All the soaps which we have hitherto mentioned are made with soda in one form or other, which alkali appears too, to have been of the most ancient use in soap-making; but there is another species in which the sole alkali is the vegetable in the form of pearl-ash, pot-ashes, wood-ashes, and the like, and in which no common salt is employed. These potash soaps, differ essentially from the others in remaining always soft and pasty however long they are kept. On this account they are not employed in common domestic uses, but are chiefly used in scouring wool, and other purposes of manufacture. However, as they are perfect soaps, and entirely soluble in water, they may be partially employed in rendering water soapy for any purpose of cleansing.

Soft soap is always coloured, generally of a brown or deep green, which however only depends on the nature of the oil used, for with olive oil it is white. It is much stronger and more acrid than the hard soaps, but in other respects it has the same chemical properties. The consistence should be that of a tenacious paste or glue, even in the hottest summer, and it should melt readily in water, forming a white and light froth. The mode of manufacture of this soap, differs in this es-

sential particular from the other, that no separation takes place between the soap and the spent ley as in the soda soaps, but the whole contents of the boiler, after sufficient boiling and evaporation are converted into soap; neither is there any of the process of framing and drying. A good deal of practical skill also (more than can be learnt from books) seems to be required in producing the proper union between the oil and alkali, and the process appears liable to sudden and often unaccountable failures as before noticed, from the refusal of the materials to unite with sufficient intimacy, or from their disunion after having already combined.

The manufacture of the best soft soap in Flanders and Picardy is thus described. The oils used in these works are linseed, hemp, poppy, coleseed and rape. Of these the two last are the cheapest and least esteemed. Fish oil also answers perfectly well, but the offensive smell of the soap made from it is so permanent, that its use is forbidden. The alkali is generally Dantzic, or Russian pearl-ash, which is mixed with lime and lixiviated till a ley strong enough to bear an egg is obtained, and only one degree of strength is used, except reserving a weaker ley for occasional dilution of the ingredients. The boilers are the same as for hard soap, and should not be filled more than half full, on account of the great rising of the contents whilst they are incorporating. The proportions of the materials are on an average about 30 parts of oil to 40 of strong ley, which yield about 65 parts of soap. The management of the boiling, and gradual addition of the ley to the oil, require considerable attention, and if it has succeeded properly, the oil and alkali unite into an uniform gluey saponaceous mass, after which the boiling is continued till enough of the watery part has evaporated to leave the remainder of the proper consistence when cold, which is known to be the case when a sample taken out and cooled does not stick to the fingers and draw out in threads, but remains brown, somewhat stiff, and granulated. The boiler is then entirely emptied, and the soap is barrelled for sale.

When the boiling has not been continued long enough, the soap is apt to ferment, and spoil by keeping.

Soap, we have said, is manufactured principally from tallow or any other fat; and the alkali employed is either barilla or pearl ash, or a mixture of the two, according to the price and practice of the manufacturer. But as potash alone will not make a stiff soap, recourse is had to the action of common salt, which, when added after the potash and oil are united, produces a separation of the compound from the water incorporated with it, hardens it, and renders it equal to the soda soaps. The process has been already mentioned.

With regard to the proportion of ingredients in making soap, it is reckoned that 16 bushels of good wood-ashes are equal in alkali to 1 cwt. of the best pearl-ash, and that this latter quantity will saturate 2 cwt. of tallow, and produce 3 cwt. 1 qr. of soap; so that 12 parts of tallow will make 20 of soap. Also, 12 bushels of wood-ashes are reckoned equal to 1 cwt. of barilla, and the latter quantity will saturate 1½ cwt. of tallow. A boil of 29 cwt. of tallow with 10 cwt. of barilla, and 5 cwt. of pearl-ash (as these alkalies are often mixed) requires about 8 cwt. of common salt.

Common salt, it is hardly necessary to repeat, appears to have two distinct uses in soap-making; one is, that of promoting the *graining*, or separation of the soap from the spent ley, which it does probably simply by abstracting the watery part. In this way it is of as much use in the soda, as the potash soaps, and in each it considerably hastens the process; but it is by no means essential, and on account of its high price appears to be seldom used, where barilla or soda is the sole alkali. But where a large portion of the alkali is potash, the soap would remain in the state of a soft pasty mass (as we have already seen) and actually does so, till the addition of common salt, which then brings the soap to the same state as the soda soaps.

It is, therefore, probable, as suggested by Pelletier, that in these cases a double decomposition takes place between the oil and potash on the one hand, and the muriatic acid and soda on the other, and that the products of this change of principles are a soap with oil and soda, and muriat of potash in the mother liquor.

In the preparation of all the hard soaps, a separation of the soap from the watery saline solution always takes place towards the end of the process, and it is this separation which enables the artist to collect and dry the soap. But the question occurs, how this separation takes place; for the liquor from which it separates is still alkaline, often very strongly so, and if the same soap, after it is fully prepared and dry, is re-dissolved in an alkaline liquor, it will mix with it uniformly into a white saponaceous fluid.

Pelletier has endeavoured to shew by some ingenious reasoning, and by experiment, that carbonic acid, which is con-

trary to many opinions, is an essential ingredient in the hard soaps, and from the fact that caustic alkali will decompose alcohol, and become more or less carbonated by the carbonic acid, which is thereby generated, (for which see the article POTASH,) he infers that during soap-boiling, the pure alkali, and oil, first unite into a saponaceous mass, during which he supposes that part of the oil is decomposed, and furnishes carbonic acid, which then unites with the saponaceous fluid, and forms with it a triple compound of oil, alkali, and carbonic acid, which constitutes hard soap. In the preparation of soap without heat, he further supposes, that part, if not all, of the carbonic acid, may be furnished by the atmosphere, which will account for the length of time required before the soap made in this way will harden and separate from the ley.

To this hypothesis, however, we may object, that there is no proof brought that soap actually contains carbonic acid, and the contrary may be inferred from its not effervescing with a stronger acid.

When a solution of soap in alcohol is poured into river or spring water, a precipitation ensues, and a great part of the precipitate is no longer soluble in water. All soaps are decomposed again by acids, and the fat matter separated from them. The alteration however, which the fat and oils undergo on this occasion, is very remarkable. They are now soluble in alcohol, whereas before, the case is quite otherwise; the cause of which depends on the action of the caloric upon these bodies; and indeed the naked fire manifestly exerts the same effect upon them in such cases, in which it converts them into empyreumatic oils.

With mere lime-water a saponaceous greasy mixture only, but no solid soap can be obtained. Besides the above-mentioned fat substances, a resinous soap may also be made from the coarser kinds of resin with caustic ley.

Chaptal gives the following classification of matters, with which soaps may be made, arranged according to the goodness of the produce.

1. Oil of olives and of almonds.
2. Suet, hogs-lard, butter and the fat of horses.
3. Rape oil.
4. Oil of beech-mast and poppy seeds.
5. Fish oil.
6. Oil of hempseed, nuts, and linseed.

The compound resulting from this union partakes at the same time of the properties of oil and of alkali; but these properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into soap, has not nearly the same acrimony as when it is pure; it is even deprived of almost all its causticity, and its other saline alkaline properties are almost entirely abolished. The same oil contained in soap, is less combustible than when pure, from its union with the alkali, which is an uninflammable body. It is miscible, or even soluble in water to a certain degree, by means of the alkali. Soap is entirely soluble in alcohol.

Concerning the decomposition of soap by means of acids, we must observe, first, that all acids, even the weakest vegetable acids, may occasion this decomposition, because every one of them has a greater affinity than oil with fixed alkali. Secondly, these acids, even when united with any basis, excepting a fixed alkali, are capable of occasioning the same decomposition; whence all ammoniacal salts, all salts with bases of earth, and all those with metallic bases, are capable of decomposing soap, in the same manner as disengaged acids are; with this difference, that the oil separated from the fixed alkali, by the acids of these salts, may unite more or less intimately with the substance, which was the basis of the neutral salt employed for the decomposition.

Soap may also be decomposed by distillation, as Lemery has shown. When first exposed to fire, it yields a phlegm called by him a spirit; which nevertheless is neither acid nor alkaline, but some water, which enters into the composition of soap. It becomes more and more coloured and empyreumatic as the fire is increased, which shows, that it contains the more subtile part of the oil.

As all oils contain an acid more or less combined, which may also be more or less disengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the soap is saturated with the acid of the oil, especially after the distillation of the soap. But this matter has not been so well examined, that we can affirm any thing concerning it.

As to the chemical properties of soap, we defer treating of them in this place, and refer the reader to chemical books.

SOAP, *Glass-maker's*. Oxyde of manganese.

SOAP OF WOOL.—In the first volume of the Memoirs of the National Institute, Mr. Chaptal has given an account of a new soap, formed by the combination of wool and an alkali. As he has entered into a detail of its uses, as well as its composition, we shall give them nearly in his own words.

In every manufactory of woollen cloths

it is usual to full the cloth immediately after it has passed the loom. The operation is performed not only for the purpose of clearing it of the oil, but to give it the requisite density. For this purpose about thirty pounds of soap are used for every eight pounds of cloth.

Hence it is obvious, how greatly beneficial it must prove to the manufacturer, to be able to substitute without difficulty, instead of the soft soap, another compound of materials, easy to be procured, and of moderate cost.

The whole operation consists in making an alkaline lixivium of wood ashes, or potash, and dissolving therein, at the boiling heat, old rags* or clippings of wool to the point of saturation. The product is a soft soap, very soluble in water, of a green grayish colour, well blended, and possessing an animal smell, which the cloths lose by washing and exposure to the air.

The various experiments I have made on this subject have presented the following results:

1. As soon as the wool is plunged into the boiling liquid, the filaments adhere together, and a slight agitation is sufficient to effect the complete solution.

2. The ley becomes coloured, and gradually thickens, in proportion as more wood is added.

3. The soap is more or less coloured, accordingly as the wool is less or more clean and white.

4. The pile, or hairs, which are mixed with the wool, are more difficult of solution.

5. The quantity of wool the alkali is capable of dissolving depends upon the strength of the lixivium, its causticity, and the degree of heat. Two pounds three ounces and six drachms of caustic alkali, at twelve degrees† of concentration, and at the boiling heat, dissolved ten ounces four drachms of wool. The soap, when cooled, weighed one pound four ounces.

An equal quantity of alkali, at the same degree of causticity, heat, and concentration, in which he dissolved four ounces of wool, did not acquire consistence sufficient to answer several of the purposes required

An equal quantity of alkali, marking four degrees, dissolved only two ounces seven drachms of wool. The soap, when cooled, weighed fourteen ounces. It was of a good consistence.

6. In proportion as the wool is dissolved in the lixivium, the solvent power of the alkali decreases, and at last it takes up no more. It is at this period, namely, when the wool being agitated in the fluid is no longer dissolved, that the operation must be terminated.

I. *The Choice and Preparation of Materials.*

The materials required to form this soap are two, alkaline matters and wool.

The alkaline substances may be obtained from the ashes of common c linary fires, and the ley made by the well-known processes. Lime is to be slaked with a small quantity of water; the paste is to be mixed with sifted wood-ashes, in the proportion of one part of quicklime by weight to ten of the ashes. The mixture is to be put into a small stone trough (for wooden vessels colour the ley and become speedily useless), and water is to be poured on to the depth of some inches. After a certain time the solution may be drawn off at an aperture in the bottom of the vessel for this purpose. It must not be drawn off till the moment previous to its use, and may be in strength from four to fifteen degrees. But indeed it is of little consequence what the strength may be, because the only difference resulting from the use of a weak or strong ley is, that the quantities of wool which are dissolved will differ accordingly.

The potash of commerce may be employed in the same manner, by mixing it with one-third of its weight of quicklime.

As to the choice of the wool, every one knows, that in the manufactories of woollen cloths of every kind, there are a number of operations performed, from the first washing of the material to the last package of the finished article, which occasion more or less of loss. The water in which the wool is agitated to cleanse it, the floor on which it is spread out, the warehouse where it is deposited, all afford waste wool; as do the operations of beating, carding, spinning, weaving, shearing, napping, and fulling. In all these several manipulations, we every where see a residue of wool, which, it is true, is collected

* Old woollen rags are a very cheap article in this country. But as every other kind of hair must certainly answer, and horns and hoofs probably will, there must be an immense and probably cheaper source in the refuse of the tanners, hog-butchers, horners, and comb-cutters. All these at present are used only as manure.

† Qu. By what measure? It is greatly to be wished, that all measures derived from the density of fluids were reduced to the common expression of the tables wherein water is taken as unity, or 1000.

with some care; but many of these operations are of such a nature, that the remains of wool they afford are solid and mixed with foreign matters, or else cut and rendered too short to enter into other fabrics, so that they are mostly thrown on the dunghill. This manufacture of soap affords the means of converting them all to use. Nothing more is required but to collect them all in those baskets in which the wool is washed, and to wash them with care for the purpose of separating impurities and foreign substances: after which they are to be reserved for this use.

The cuttings of all the woollen stuffs afforded by the shops of manufacturers, dealers, tailors, and the like, may be advantageously collected for this purpose: and the same advantage may be derived from the remains of garments after they are worn out.

II. *Method of Making the Soap.*

When the ley and the wool are both ready, it remains only to cause the ley to boil in a vessel of the common form. When it has arrived at this point, the wool is to be added by small quantities at a time, and agitated to cause a more speedy solution. Care must be taken not to add more wool, until the first portions are dissolved. The operation must be stopped the moment the liquor refuses to dissolve more.

From the operations in the large way, made by Michael Fabréguettes, with soaps of his own fabrication, after the method I communicated to him, it is certain, that this soap cleans, felts, and supples the cloths perfectly well. But its use requires a few important observations to be made.

1. When the soap is not made with the requisite care, or when dirty or coloured wool has been employed, the cloth receives from the soap a gray tinge, which it is very difficult to eradicate. This tinge is of no consequence when the cloth is intended to be dyed; but it would injure the beauty of that white colour, which in certain goods is intended to be preserved. The remedy consists in employing the most select materials, to form the soap intended for such uses.

2. Cloths fulled with this soap contract an animal odour, which, though not very strong, is nevertheless disagreeable; but water and the air completely remove it.

After having succeeded in the employ of this soap in fulling cloths made of wool, I attempted to substitute soda for potash, and to form, according to the process here described, a solid soap, proper for the operation of dyeing cottons. My experiments have succeeded beyond my hopes.

Forty-six pounds of soda at eight degrees dissolved at the temperature of ebullition five pounds of wool, and afforded by cooling sixteen pounds fourteen ounces of soap sufficiently solid not to spread (*couler*).

The first wool which is thrown into the soda dissolves readily, but it is afterward seen, that the fluid gradually becomes thicker, and that the dissolution becomes more difficult and slow.

The first solutions render the liquor green, after which it becomes black, and the soap when cooled preserves a blackish green colour.

This soap has been employed in every manner, and under every form, in my manufactory for dyeing cottons; and I am at present convinced, that it may be substituted, instead of the saponaceous liquid we make from the lixivium of soda and oil, to prepare the cottons. I have constantly observed, that by dissolving a sufficient quantity of this soap in cold water to render the fluid milky, and by working the cotton in the manner well known, it is sufficient to pass the cotton three times through, drying at each time, in order that it may be as well disposed to receive the dye, as that which has been passed seven times through the ordinary solusion of soap. This will not appear surprising, when it is considered, that animal matters are very proper to dispose thread and cotton to receive the dye, and that some of the operations of our dye-works consist simply in impregnating them with these substances.

It is to be observed, that cotton, which has passed through a solution of this soap, acquires a gray tinge, nearly similar to what it gains by aluming, while the common soap-colours give it the most beautiful white colour. But this gray colour is not at all prejudicial to the dyeing processes, as we have remarked in speaking of woollens.

Besides alkaline soaps, there are also earthy and metallic soaps, which are not used in the arts.

SOAPS, *Essential-Oil.* STARKEY'S SOAP.—The combination of the essential oils with the fixed alkalies is much more difficult than that of the expressed oils and fats, and much less perfect, so that a separation is liable to take place, whatever pains be taken in the mixture. This kind of soap was first introduced by an alchemist of the name of *Starkey*, whence it has taken its name. Starkey's process was tedious and uncertain. It consisted

in putting in a vessel some dry carbonat of potash with oil of turpentine, and shaking the mixture daily for six months, during which time part of the oil combines with the alkali into a saponaceous mass, and the remainder floats above it unaltered. Beaumé has taken a good deal of pains to find out the best method of making this mixture. His method is the following. Put in a marble mortar, or on a porphyry stone, any quantity of dry carbonat of potash, add to it gradually twice or thrice its weight of oil of turpentine, and rub them together till the mixture has the consistence of a soft extract; then put it into a glass cucurbit, and set it (at rest) in a damp place, during which the mixture absorbs much moisture from the air, and resolves itself into three portions, the lowest of which is a watery solution of the alkali, the middle is the soap required, and the upper portion is some uncombined oil of turpentine, generally yellow or amber-coloured. Pour the whole on a strainer of double cloth, and the soap alone remains on the strainer, which, after draining for some days, must be again rubbed in a mortar, and is then complete. The alkaline liquor that runs through the filter is somewhat impregnated with the oil. Other recipes have been given for this soap, the preparation of which has engaged more attention, perhaps, than it merits as a medicine, and which need not be repeated in this place. This soap has an acrid alkaline taste, and is very apt to deliquiate on exposure to air.

It does not appear, however, that the solid caustic alkalies have ever been used for this purpose, so that experiments are still wanting to ascertain the precise action of the alkalies on the essential oils.

SOAP, *Windsor*.
SOAP OF SODA, or HARD SOAP.
SOAP OF POTASH, or SOFT SOAP.
} See SOAP.

SOAP-LEES. *Lixivium saponarium*.—This term has been not unfrequently used both by chemical writers, and also familiarly, to signify the *ley* or alkaline lixivium used by soap-boilers. In this country, therefore, it means a very strong solution of potash, nearly, if not entirely, caustic; but in the countries where soda is chiefly used by the soap-makers, it signifies a ley of caustic soda. It is therefore an incorrect term, and is nearly disused.

The term *soap-lees* is also employed technically by some to signify the *spent ley* which is pumped out of the soap cistern after the soap has separated, and being generally more or less alkaline, it is never thrown away, but is sometimes used again in the state in which it is obtained, and at other times is evaporated, and the residue calcined to extract the alkali. But owing to the decomposition of common salt, in the formation of hard from soft soap, the *spent ley* always contains muriat of potash.

SODA.—This was formerly called the mineral or fossil alkali, because supposed to belong exclusively to that kingdom: by the London college it is termed natron, as there are sufficient grounds for concluding, that it was the natron, or nitrum, of the ancients, which was long confounded with our nitre; but the French name soda has generally prevailed.

Soda is found native in many hot countries, subsaturated with carbonic acid; and in the water of the sea, in very large quantity, saturated with the muriatic acid. But in Europe it is generally obtained from plants, that grow in the sea or on its shores. In Scotland sea-weeds of different kinds are selected, dried, and burned in pits dug in the sand, or in heaps surrounded with loose stones. Fresh quantities are added, as the first are consumed, the whole being frequently stirred, till it becomes semifluid; and when cold it concretes into hard masses. This impure alkali, which is of a black or blueish colour, is called kelp, and does not contain more than from $2\frac{1}{2}$ lbs. to 5 lbs. of soda in 100.

On the southern coasts of France, and more particularly of Spain, different plants chiefly of the salsoza genus are cultivated for the purpose of manufacturing this salt. These are burned in much the same manner, and the saline produce they yield is termed barilla. That of Alicant is in the highest repute. If the plants that thus produce soda be removed to an inland situation, the soda they yield by burning gradually decreases, till at length they afford no other alkali than potash.

From this barilla, or from kelp, the salt is extracted by lixiviation with boiling water, filtration, and crystallization. A pound of barilla will yield from three to five ounces of carbonat of soda. This, being crystallized, is less impure than the carbonat of potash, extracted in a similar manner.

To extract the carbonic acid, and obtain the soda pure, quicklime is used. This, first slaked by the addition of a little water, is mixed with an equal weight of the carbonat of soda, and as much water as will make the whole a thin paste. The mixture being poured into a funnel with a filter of linen cloth, more water is to be added as the solution passes through,

till five or six times the weight of the carbonat have been employed. If the soda be required very pure, this solution must be evaporated to the consistence of honey, and about an equal quantity of alcohol added. After these have stood a little time in a close vessel, the lighter fluid on the top is to be poured off from the darker beneath and the solid matter at the bottom, and part of its alcohol abstracted by distillation. The remainder on standing will again separate into two portions; and that which floats like an oil on the surface, being a solution of the pure soda in alcohol, is to be poured off and evaporated in a silver vessel, so as to obtain the alkali in crystals, which are prismatic, but not very regular, or in thin plates.

The soda is white, extremely acrid and caustic, powerfully attractive of water, and capable of being fused and volatilized by heat. With oil it forms soap, and with siliceous earth glass.

From the uses to which soda has been applied in the arts, various modes have been suggested of obtaining it in the large way. Mr. Accum says he has been employed in a soda manufactory, in which the following method answered exceedingly well: Five hundred pounds of sulphat of soda were introduced into an iron boiler, containing a sufficient quantity of Thames water. Five hundred and sixty pounds of American potash were likewise dissolved in as little water as possible, in an iron boiler, fixed near the former. The potash was always previously tried, and, if indifferent, the quantity taken was ten pounds more.

The solution was made with about thirty pails of water to the alkali here mentioned. Both solutions were then made to boil, and as soon as the ebullition took place, the solution of potash was ladled into the boiler containing the sulphat of soda. The mixture was agitated during the transfusion, and the fire raised as expeditiously as possible.

As soon as the fluid boiled, it was ladled into a wooden gutter, which conveyed it into a cistern of wood lined with sheet lead nearly half an inch thick, which was fixed in a cool place. Sticks of wood were then placed across the cistern, from which slips of sheet lead two or three inches wide were hung into the fluid, at four inches distant from each other. When all was cool, which in the winter was generally the case in three days, a plug in the bottom of the cistern was drawn, in order to let off the fluid, and the crystallized salt was taken from the slips of lead. The bottom exhibited a rock of salt, which was detached by chisel and mallet. On this account it is, that the lead which lines the cistern must be thick, in order to guard against accidents. For, if the metal be perforated, the saline solution creeps between it and the wood, and in a very short time detaches the lining; and it is besides extremely difficult to find out the place where the defect really is. The temperature where the soda is left to crystallize, ought not to exceed 55° Fahrenheit.

In this stage of the process the whole of the salt is washed in the same cistern with cold water, to clear it of impurities; after which it is transferred again into the boiler, dissolved in clear water, and evaporated by heat. As soon as a strong pellicle is formed, it is suffered to cool so far, that the hand may be dipped in the fluid without injury, and the heat is kept at that temperatare as long as effectual pellicles continue to be formed over the whole surface of the boiler, and then fall to the bottom.

When no more pellicles are formed, or at least only by blowing with the mouth upon the surface, the fire is withdrawn, and the fluid is ladled out into the cistern to crystallize. The sulphat of potash, &c. which had been deposited, are then taken out of the boiler, and put aside. If the fluid be suffered to cool pretty low, before it is allowed to run into the cistern, very little sulphat of potash is found in the soda; but in general the rocky masses of soda met with in the market contain a considerable quantity. By this process from 136 to 139 pounds of soda may be obtained from 100 pounds of sulphat of soda, if the soda be crystallized in large crystals; if small crystallized, it yields less.

We might be inclined to suppose, that the first operation was unnecessary, and that the soda might be separated at once from the sulphat of potash at the instant of the formation; but practice will convince the operator otherwise. A considerable loss is manifested, if the process be not conducted in this manner; though the discovery of the cause may perhaps be not so easily accomplished as the proof of the fact,

Other manufacturers grind together five cwt. of Glauber's salt of the bleachers, and one cwt. of charcoal: they expose this mixture in a reverberatory furnace resembling a bake oven, till the matter, when stirred with a rake, becomes pasty. It is then withdrawn and transferred into large casks, each provided with a double bottom. Water is then suffered to stand one inch high over it for twenty-four hours; the cock is then opened, the solu-

tion runs through the perforated bottom, over which a stratum of straw had been previously placed; and is thence conducted into the boiler for evaporation and crystallization.

It is a curious fact, that iron plates are absolutely necessary to constitute the surface, on which these articles are exposed to heat: fire-bricks do not answer. It seems as if iron assisted the union; though neither iron filings mixed with the articles, nor pyrites, are found of advantage.

This method of making soda is extremely uncertain. If the heat be not raised gradually, or if the mixture be not fused enough, or a little too much, it does not succeed. The worst event is, that when the mixture has been made too hot, sulphuric acid is produced, and sulphat of potash is formed.

The quantity of soda which may be obtained by this process, is said to be equal to that obtained by any other method.

We have lately been informed, that in Germany soda is made by decomposing the sulphat of soda by means of acetite of lime; the acetic acid is obtained for this purpose from wood, and the charcoal is found to pay the expenses.

The method recommended by several chemists, of obtaining soda by decomposing sulphat of soda by the oxides or acetite of lead, does not answer in this country. The mass is by far too bulky; and requires too much time, attendance, and fuel, to reduce it to a narrow compass.

SOIL. See Agriculture.

SOLDER, SOLDERING. The art of soldering is that of joining together two or more pieces of metal by means of a metallic cement; hence it is absolutely requisite, that the solder employed should have the two following qualities, viz. that of being fusible at a lower heat, than the metals which it is intended to cement, and of adhering with considerable firmness to their surfaces. The solder for gold is composed of fine gold, with $\frac{1}{4}$ or $\frac{1}{2}$ its weight of fine silver, mixed together accurately by fusion, and afterwards beat out into leaves, somewhat thinner than card paper, and rendered as soft as possible by annealing. It is made use of in the following manner. A piece of solder of the proper size and shape being cut off, is laid on the part to be cemented and sprinkled over with pulverized borax; the flame from a blow-pipe is then applied, and the borax and solder both enter into fusion, the latter incorporating with, and adhering firmly to the gold: when the juncture is complete the piece is allowed to cool, and the borax is removed by boiling water, or what is still better a little dilute sulphuric or muriatic acid.—The solder will however appear considerably paler than the other part, both on account of the silver with which it is alloyed, and of the borax, which always lowers the colour of gold: this defect may be remedied by melting on the surface of the solder, a mixture of two parts of nitre, and one of burnt alum, and afterwards washing it off with a soft brush and hot water, by which the natural colour of the gold, will be restored and even heightened.

For silver there are two kinds of solder employed, the hard and the soft. The former is composed of equal parts of silver and fine brass; and the latter is prepared by fusing the hard solder with one-sixteenth of its weight of pure zinc. Th mode of applying it, is the same as already directed for gold solder.

For copper, brass, and the hard alloys of copper, the best hard solder is composed of brass and zinc, in the proportion of from 8 to 16 of the former, to one of the latter, according to the required hardness. The soft solder is composed of 3 parts of zinc and one of lead, and is applied by means of a common soldering iron, heated red hot.

The solder for tin, pewter, and lead, (or the plumber's solder,) is of two kinds: the least fusible is composed of equal parts of tin and lead; the more fusible contains besides, bismuth in various proportions. A very good soft solder is prepared, by melting together sixteen parts of tin, eight of lead, and four of bismuth.

For delicate works in cut steel, the best solder is gold, with a high alloy of copper. For larger works in iron and steel, copper is made use of, or an alloy composed of equal parts of tin, and iron.

The following solders, from Imison, may be useful.

To make Silver Solder.

Melt fine silver two parts, brass one part; do not keep them long in fusion, lest the brass fly off in fumes.

Another for Coarser Silver.

Melt four parts of fine silver, and three of brass; throw in a little borax, and pour it out as soon as it is melted.

A Solder for Gold.

Melt copper one part, fine silver one part, and gold two parts; add a little borax when it is just melted, then pour it out immediately.

The Method of Soldering Gold or Silver

After the solder is cast into an ingot, it would be more ready for use, if you were to draw it into small wire, or flat it between two rollers; after that cut it into little bits, then join your work together, with fine soft iron wire, and with a camel's hair pencil, dipt in borax finely powdered, and well moistened with water, touch the joint intended to be soldered: placing a little solder upon the joint, apply it upon a large piece of charcoal, and with a blow-pipe and lamp, blow it upon the flame, until it melts the solder, and it is done.

To cleanse Silver or Gold, after it is Soldered.

Make it just red-hot, and let it cool, then boil it in alum-water, in an earthen vessel, and it will be as clean as when new. If gold, boil it in urine and sal ammoniac.

A Solder for Lead.

Two parts lead and one part tin: its goodness is tried by melting it, and pouring the bigness of a crown piece upon the table; if it be good, there will arise little bright stars in it. Apply resin when you use this solder.

A Solder for Tin.

Take four parts pewter, one of tin, and one of bismuth; melt them together, and run them into narrow thin lengths.

SOUP, PORTABLE See GELATIN.

SOUR WATER. Water is rendered acidulous by fermenting with bran, a preparation much used in dyeing. Twenty-four bushels of bran are put into a tub or vat, that will contain about ten hogsheads: a large boiler is filled with water, which, when just ready to boil, is poured into the vat: the acid fermentation soon commences, and in 24 hours the liquor is fit for use.

SOWANS. This very nutritious article of food is made in Scotland, from the husk of oats, by a process not unlike that by which common starch is made. The husk of the oat, called seeds, is separated from the oat meal by the sieve; but it still contains a considerable portion of farinaceous matter. It is mixed with water, and allowed to remain for some days, till the water has become sour. The whole is then thrown upon a sieve; and the milky water passes through, but all the husk remain behind.

The water thus obtained, is loaded with starchy matter, which soon subsides to the bottom. The sour liquor is decanted off, and about an equal quantity of fresh water is added. This mixture when boiled, forms a very nutritious article of food; and the portion of the sour water, which still adheres to the starch, gives the whole a pleasant acidity.

It is observable, that the starch maker's sour water, notwithstanding the great quantity of acid it contains, and the still sourer water of sowans, are swallowed greedily by hogs, and they fatten upon it.

SOY. We find in the Memoirs of the Swedish Academy the following account of the mode, in which this kind of sauce is prepared.

The ingredients are fifty pounds of a small white bean, the fruit of the *dolichos saja*, fifty pounds of salt, sixty pounds of wheat flour, and two hundred and fifty pounds of water.

After having well washed the beans, they are boiled in well-water in an open vessel for some hours, or until they have become so soft, as to be worked between the fingers. During the boiling they must be kept covered with water, to prevent their burning; and care must be taken, not to boil them too much, because in that case, too much of their substance would remain in the water of decoction.

The beans being thus boiled, are taken out, and put into large shallow wooden vessels, which in China are made of thin staves of bamboo, two inches and an half in depth, and five feet in diameter. In these they are spread out to the depth of two inches, and when they are cold enough to be worked with the hand, the wheat flour is gradually thrown in, and mixed with the beans, till the whole of the before-mentioned quantity has been used. When the mass becomes too dry, so that the flour does not mix well with the beans, a little of the hot water of the decoction is added.

The whole being well mixed, the mass is spread abroad in the vessels before-mentioned, taking care that its depth shall not be more than an inch, or an inch and a half; and it is then covered by a lid, which fits exactly. When the mass begins to grow mouldy, and heat is disengaged, which happens after two or three days, the cover is raised, by putting two sticks beneath it, in order that the air may have free access.

During this time a rancid odour exhales: and if the mass become green, it is a sign that the whole goes on properly; but if it begins to be black, which must be carefully noticed, the lid must be rais-

ed higher, in order that the mass may have still more air. If it once becomes black, the whole is spoiled.

As soon as all the surface is covered with green mouldiness, which usually happens in eight or ten days, the cover is taken off, and the compound is exposed to the sun and air for several days. When it has become as hard as a stone, it is cut into small fragments, which are thrown into an earthen vessel, upon which the two hundred and fifty pounds of water, having the fifty pounds of salt, first dissolved in them, are poured The whole is then well stirred together, and notice is taken of the height at which the water stands. If it be not convenient to put all the mixture into one vessel, a number may be used, taking care that the materials be proportionally distributed in each.

The vessel thus filled is placed in the sun, and its contents stirred up regularly every morning and evening; and a cover is put on at night to defend it from the cold, as well as to prevent any rain from finding entrance, either by day or night. The hotter the sun, the sooner will the soy be completed. The process is seldom undertaken but in summer, notwithstanding which it lasts two or three months.

As the mass diminishes by evaporation, well-water is added; and this digestion is continued, till the salt water has entirely dissolved the flour and the beans. The vessel is still left for some days in the sun, in order to complete the solution still more effectually, as the good quality of the soy depends upon this circumstance; and the daily stirring or agitation is continued to the very last.

When at length the mass has become very succulent and oily, the whole as well the thick as the more fluid portions, is poured into bags, through which the soy is pressed, and is then clear and ready for use. It is not afterwards boiled, as Mr. Eckeberg pretends. It is to be kept in bottles well corked. The Chinese, who deal in this article, keep it in large pitchers well closed. Before it is strained in the press, the soy is of a deep brown colour, but afterwards it becomes black.

The Chinese also prepare two kinds of soy from the dregs which remain: The first time they add one hundred and fifty pounds of water, and thirty pounds of salt, and after having pressed the mass, they again add one hundred pounds of water, and twenty pounds of salt, always proceeding as before described.

The two last kinds of soy are not strong, but very salt, more especially the latter, which is also lighter coloured. These two kinds are the most common in China, and are used both by natives and Europeans. The differences of price are as 8, 4, and 1.

SPANISH BROWN. See Colour Making.

SPANISH SHEEP. See Sheep and Animals, Domestic.

SPANISH WHITE. The substance originally called by this name, is the white oxyd or magistery of bismuth, the name is often however applied to washed chalk or whiting.

SPAR. The term spar, in its more comprehensive sense, appears to include almost all the earthy crystallized minerals, that are met with in metallic veins; but by mineralogists it is applied to those minerals, whether earthy or metallic; which are crystallized and have a visible foliated texture. Thus we say calcareous spar, fluor spar, heavy spar, felspar, lead spar, spathose iron, &c. but not quartz spar. It is not however, every foliated crystal which is called a spar, for neither mica nor hornblende bear this appellation. The adjective spathose or sparry, means composed of crystalline plates, in opposition to foliated or slaty, which only imply composed of plates, without any reference to crystallization.

SPECIFIC GRAVITY. Boyle is among the first of our philosophers, who suggested the advantage, that chemistry and mineralogy, might derive from an attention to the specific gravity of bodies.—Much advantage may be derived from this property in the general determination of the classes of minerals, and the purity of some metallic bodies; and it is very probable, that attention to the specific gravities, capacities for heat, fusibilities, volatilities, laws of crystallization, elasticity, hardness, tenacity, malleability, and some other obvious specific properties of bodies, may produce a more intimate acquaintance with the mutual actions of their particles, than any we have hitherto acquired.

The specific gravity of solids, is determined by weighing them first in air, and then in water. The loss of weight, arising from the action of the water, is equal to that of a mass of the fluid, possessing the same dimensions as the solid itself. Whence it is easy to construct a general table of specific gravities, by reducing the proportion of the absolute weight, to the loss sustained by immersion, into terms of which that expressing water shall be unity. If the solid be so light as to float upon water, it is convenient to attach to it a heavier body, sufficient to cause it to sink, but the weight of which in water,

must be added in computing the loss. The specific gravity of fluids is ascertained, by weighing a known body immersed in them. For the loss by immersion will accurately show the weight of the same bulk of the fluid; and, consequently, the proportion of these several quantities to the loss the same solid sustained in water, being reduced as in the other case to the common standard of unity, will exhibit the specific gravity.

Other methods are likewise used in experiments with fluids. Thus equal bulks of different fluids, may be weighed by filling a small bottle with a ground stopper, with each respectively, and from their several weights, the weight of the bottle and stopper must be deducted. Or otherwise, the instrument called the hydrometer, may be used. See HYDROMETER. This possesses the advantage of portability, speed, and a degree of accuracy not easily obtained, by the use of ordinary balances.

SPECTACLES. Spectacles restore and preserve to us one of the most noble and valuable of our senses; they enable the mechanic to continue his labour, and earn a subsistence by the work of his hands, till the extreme of old age. By their aid, the scholar pursues his studies, and recreates his mind with intellectual pleasures, and thus passes away days and years with delight and satisfaction, that might otherwise have been devoured by melancholy, or wasted by idleness.

Some eyes require the assistance of convex glasses to make them see objects distinctly, and others of concave. If either the cornea or crystalline humour, or both of them, be too flat, their focus will not be on the retina, where it ought to be, in order to render vision distinct; but beyond the eye. Consequently those rays which flow from the object, and pass through the humours of the eye, are not converged enough to unite, and therefore the observer can have but a very indistinct view of the object. This is remedied by placing a convex glass before the eye, which makes the rays converge sooner, and imprints the image duly on the retina.

If either the cornea, or crystalline humour, or both of them, be too convex, the rays that enter in from the object, will be converged to a focus in the vitreous humour; and by diverging from thence to the retina, will form a very confused image thereon; and so, of course, the observer will have as confused a view of the object, as if his eye had been too flat. This inconvenience is remedied by placing a concave glass before the eye; which glass, by causing the rays to diverge between it and the eye, lengthens the focal distance so, that if the glass be properly chosen, the rays will unite at the retina, and form a distinct picture of the object upon it.

Such eyes as have their humours of a due convexity, cannot see any object distinctly at a less distance than six inches; and there are numberless objects too small to be seen at that distance, because they cannot appear under any sensible angle.

General Rules for the Choice of Spectacles.

The most general, and, perhaps, the best rule that can be given, to those who are in want of assistance from glasses, in order so to choose their spectacles that they may suit the state of their eyes, is to prefer those which show objects nearest their natural state, neither enlarged nor diminished, the glasses being near the eye; and that give a blackness and distinctness to the letters of a book, neither straining the eye, nor causing any unnatural exertion of the pupil.

For no spectacles can be said to be properly accommodated to the eyes, which do not procure them ease and rest: if they fatigue the eyes, we may safely conclude, either that we have no occasion for them, or that they are ill made, or not proportioned to our sight.

Though, in the choice of spectacles, every one must finally determine for himself which are the glasses through which he obtains the most distinct vision; yet some confidence should be placed in the judgment of the artist of whom they are purchased, and some attention paid to his directions.

Of Preservers, and Rules for the Preservation of Sight.

Though it may be impossible to prevent the absolute decay of sight, whether arising from age, partial disease, or illness; yet by prudence and good management, its natural failure may certainly be retarded, and the general habit of the eyes strengthened, which good purposes will be promoted by a proper attention to the following maxims.

1. Never to sit for any length of time in absolute gloom, or exposed to a blaze of light. The reasons on which this rule is founded, prove the impropriety of going hastily from one extreme to the other, whether of darkness or of light, and show us that a southern aspect is improper for those whose sight is weak and tender.

2. To avoid reading small print.

3. Not to read in the dusk; nor, if the eyes be disordered, by candle-light.—Happy those who learn their lesson betimes, and begin to preserve their sight, before they are reminded by pain of the necessity of sparing their eyes; the frivolous attention to a quarter of an hour of the evening, has cost numbers the perfect and comfortable use of their eyes for many years: the mischief is effected imperceptibly, the consequences are inevitable.

4. The eye should not be permitted to dwell on glaring objects, more particularly on first waking in a morning; the sun should not, of course, be suffered to shine in the room at that time, and a moderate quantity of light only should be admitted. It is easy to see, that for the same reasons the furniture of a bed should be neither altogether of a white or red colour; indeed, those whose eyes are weak, would find considerable advantage in having green for the furniture of their bedchamber. Nature confirms the propriety of the advice given in this rule; for the light of the days come on by slow degrees, and green is the universal colour she presents to our eyes.

5. The long-sighted should accustom themselves to read with rather less light, and somewhat nearer to the eye, than what they naturally like; while those that are short-sighted should rather use themselves to read with the book as far off as possible. By these means, both would improve and strengthen their sight; while a contrary course will increase its natural imperfections.

There is nothing which preserves the sight longer than always using, both in reading and writing, that moderate degree of light which is best suited to the eyes; too little strains them, too great a quantity dazzles and confounds them. The eyes are less hurt by the want of light than by the excess of it; too little light never does any harm, unless they are strained by efforts to see objects, to which the degree of light is inadequate; but too great a quantity has, by its own power, destroyed the sight. Thus many have brought on themselves a cataract, by frequently looking at the sun, or a fire; others have lost their sight, by being brought too suddenly from an extreme darkness into the blaze of day. How dangerous the looking upon bright luminous objects is to the sight, is evident from its effects in those countries which are covered the greater part of the year with snow, where blindness is exceedingly frequent, and where the traveller is obliged to cover his eyes with crape, to prevent the sudden, and often dangerous effects of too much light: even the untutored savage tries to avoid the danger, by framing a little wooden case for his eyes, with only two narrow slits. A momentary gaze at the sun will, for a time, unfit the eyes for vision, and render them insensible to the impressions of a milder nature.

The following cases from a small tract on the Fabric of the Eye, are so applicable to the present article, as to want no apology for their insertion here; though, if any were necessary, the use they will probably be of to those whose complaints arise from the same, or similar causes, would, we presume, be more than sufficient.

"A lady from the country, coming to reside in St. James's square, London, was afflicted with a pain in the eye, and a decay of sight. She could not look upon the stones, when the sun shone upon them, without great pain. This, which she thought was one of the symptoms of her disorder, was the real cause of it. Her eyes, which had been accustomed to the verdure of the country, and the green of the pasture-grounds before her house, could not bear the violent and unnatural glare of light reflected from the stones; she was advised to place a number of small orange trees in the windows, so that their tops might hide the pavement, and be in a line with the glass. She recovered by this simple change in the light, without the assistance of any medicine, though her eyes were before on the verge of little less than blindness."

"A gentleman of the law had his lodgings in Pall-mall, London, on the north side; his front windows were exposed to the full noon sun, while the back room, having no opening but into a small close yard surrounded with high walls, was very dark; he wrote in the back room, and used to come from that into the front to breakfast, &c. His sight grew weak, and he had a constant pain in the balls of his eyes; he tried visual glasses, and spoke with occulists equally in vain. Being soon convinced, that the coming suddenly out of his dusky study into the full blaze of sun-shine, and that very often in the day, had been the real cause of the disorder, he took new lodgings; by which, and forbearing to write by candle-light, he was very soon cured."

Blindness, or at least miserable weakness of sight, is often brought on by these unsuspected causes. Those who have weak eyes should, therefore, be particularly attentive to such circumstances,

since the prevention is easy, but the cure may be difficult, and sometimes impracticable.

Whatsoever care, however, be taken, and though every precaution be attended to with scrupulous exactness; yet, as we advance in years, the powers of our frame gradually decay: an effect which is generally first perceived in the organs of vision.

Age is, however, by no means an absolute criterion, by which we can decide upon the sight, nor will it prove the necessity of wearing spectacles. For, on the one hand, there are many whose sight is preserved in all its vigour, to an advanced old age; while, on the other, it may be impaired in youth by a variety of causes, or be vitiated by internal maladies Nor is the defect either the same in different persons of the same age, or in the same person at different ages; in some the failure is natural, in others it is acquired.

From whatever causes this decay arises, an attentive consideration of the following rules will enable every one to judge for himself, when his sight may be assisted or preserved by the use of spectacles.

1. When we are obliged to remove small objects to a considerable distance from the eye, in order to see them distinctly.

2 If we find it necessary to get more light than formerly; as, for instance, to place the candle between the eye and the object.

3. If on looking at, and attentively considering a near object, it becomes confused, and appears to have a kind of mist before it.

4. When the letters of a book run one into the other, and hence appear double or treble.

5. If the eyes be so fatigued by a little exercise that we are obliged to shut them from time to time, and relieve them by looking at different objects.

When all these circumstances concur, or any of them separately take place, it will be necessary to seek assistance from glasses, which will now ease the eyes, and in some degree check their tendency to grow flatter; whereas, if they be not assisted in time, the flatness will be considerably increased, and the eyes be weakened by the efforts they are compelled to make.

SPECULUM. When tin is melted with copper, it composes the compound called bronze. In this metal the specific gravity is always greater than would be deduced by computation, from the quantities and specific gravities, of its component parts. The uses of this hard, sonorous and durable composition, in the fabrication of cannon, bells, statues, and other articles, are well known.

Bronzes and bell-metals are not usually made of copper and tin only, but have other admixtures, consisting of lead, zinc, or arsenic, according to the motives of profit, or other inducements of the artist. But the attention of the philosopher, is more particularly directed to the mixture of copper and tin, on account of its being the substance, of which the specula of reflecting telescopes are made. The metal required for this purpose, ought to be capable of an exquisite polish, hard enough to receive and retain a figure accurately suited, to the regular reflection of light, and not subject to become tarnished, by the action of the atmosphere. Many excellent telescopes have been made with compositions of pure copper, alloyed with somewhat less than half its weight of tin.

But it appears to be very well ascertained, from the observations of the English astronomer royal, that the specula of Mr. Edwards, whose composition was the result of numerous trials, are much superior to any which have yet been made, and are even equal in light to achromatic telescopes of the same aperture, without altering the colours of objects. He first melts thirty-two parts of copper as fluid as possible, with one part of brass, and one of silver, together with the black flux; at the same time that fifteen parts of tin are melted in a separate crucible. These being taken from the fire, he pours the tin to the copper; immediately stirs the whole together with a wooden spatula, and pours it out hastily into a large quantity of cold water, which cools and granulates the composition. If the tin was fused together with the copper, or if they were to remain for any length of time in the extreme heat which is necessary to fuse this last metal, a part of the tin would be oxided, and the metal would abound more or less with small microscopic pores. If one of the pieces of the cold metal be broken, it will appear a most beautiful bright colour, resembling quicksilver.—Mr. Edwards affirms, that different kinds of copper, require different doses of tin, to produce the most perfect whiteness. If the dose of tin be too small, which is the fault most easily remedied, the composition will be yellowish; if it be too great, the composition will be of a gray blue colour, and dull appearance. He therefore finds by trial, the quantity of tin necessary to be added in the second fusion, to render the metal the more per-

fect. A much less degree of heat is then required to melt the compound. In the second melting he adds one part of arsenic, and immediately stirs the mixture; which he pours into the mould as soon as the fumes of the arsenic have ceased to rise. He casts the speculum in sand, with the face downwards; takes it out while red-hot, and places it in hot wood ashes to cool: without which precaution it would break in cooling.

Mr. Little recommends the following proportions: 32 parts of the best bar copper, four parts of the brass of pin-wire, sixteen and a half of tin, and one and a quarter of arsenic. Silver he rejects, as it has an extraordinary effect of softening the metal; and he found that the compound was not susceptible of the highest polish, unless it was extremely brittle. He first melts the brass, and adds to it about an equal weight of tin When this mixture is cold, he puts it into the copper, previously fused with black flux, adds next the remainder of the tin, and lastly the arsenic. This mixture he granulates, by pouring into cold water, as Mr. Edwards did, and fuses it a second time for casting.

As the construction of telescopes is foreign to the immediate purpose of this work, it has not been thought necessary to mention the several precautions of Mr. Edwards in this business; but the curious operator, who may wish to undertake the construction of a reflecting telescope, (the better kinds of which are not only difficult to be procured, but of considerable price,) may have recourse to Edwards's treatise, annexed to the Nautical Almanack for 1787; where he will find ample instructions for that purpose. He may likewise consult the Rev. Mr. James Little's paper, in the 10th volume of the Irish Transactions.

The composition of metal for specula, previous to the invention of the reflecting telescope, was in the hands of artists, and did not acquire that extreme perfection, with regard to density and other properties, which the specula of those instruments demand. Experience showed them, that arsenic is a valuable ingredient in these mixtures; but speculative philosophers, reasoning from the saline property of that substance before it was known, that it can be reduced to a metal, were apprehensive that it would increase the disposition to tarnish. We conjecture, that Mr. Edwards's composition might be improved, by a greater proportion of arsenic, or at least by adding this ingredient in an earlier stage of the process. For this reason, we shall here insert the directions which Blancourt in his Art of Making Glass, gives as the best of all compositions for whiteness, hardness, and susceptibility of an exceeding fine polish. As we do not answer for the value of this receipt, we shall give it in the author's own words, after remarking, that the oil of tartar is evidently unnecessary; that the gradual management of the heat on a sand bath, is probably a useful refinement; that the substitution of orpiment for arsenic, as he recommends, must be noxious; that by latten we understand common brass, of which there are various kinds; and that the addition of the tin, should be made in the fused state.

Take plates of copper, one pound, mince them, that they may be put into a crucible, imbibing them with oil of tartar; then powder a quarter of a pound of white arsenic, and put these stratum super-stratum, until you fill the crucible; pour on them afterwards linseed oil, to cover the arsenic and the copper: head and lute your crucible; and when the lute is dry set it on a sand furnace. letting the sand arise no higher than the head; heat the furnace gently, till it arrives at a just degree, and the oil begins to evaporate; by this time the oil will prepare the copper for retaining the arsenic, which must enter the copper, as easily as oil does leather; set it again on fresh sand, and increase the heat of the furnace, giving it the same degree as before, until the oil evaporates and boils up; then take off the crucible, let it cool, and break it, you will find your copper of several colours. It would be much better, if instead of arsenic, you make use of orpiment.

Take of this copper one part, of latten two parts, melt the latten on a smart fire, and so put in the copper; when they are well melted, cast the metal drop by drop, into a glazed earthen vessel full of water, over which lay a bush or broom for the stuff to go through; thus you will have a metal not to be touched with a file, nor brittle, as good as any steel for all uses whatever.

Take of this hard metal, three parts, and best tin of Cornwall, which has no lead in it, one part; melt the metal before you put in the tin: after these are well incorporated, you may fill your moulds, &c.

SPELTER. Zinc is called spelter in commerce. The soft brass containing a redundant proportion of zinc, and sold in the granulated form for the use of artists in soldering, is called spelter solder, and frequently spelter only.

SPERMACETI. This peculiar oily substance is found abundantly in the cra-

nium of the Cachalot or Spermaceti Whale, (Physeter macrocephalus, Linn.) and in some other species of the same genus: but though contained in the cavities of the scull, it appears to be entirely different from the proper brain of the animal.—When first extracted, it is mixed with a considerable quantity of oil which is separated by putting the mass into a woollen bag and pressing it, by which the greatest part of the oil runs out, and then washing the residue with a warm weak alkaline ley, which dissolves and converts into soap the remainder of the oil, leaving behind the spermaceti untouched; this latter after being repeatedly washed with soft water, is melted by a very gentle heat, the impurities partly float on the surface, and partly sink to the bottom, and are thus got rid of; the fluid, in appearance a perfectly pellucid oil, is now allowed to cool, and forms on congealing, a mass of purified spermaceti.

Spermaceti is of use in medicine, though chiefly externally.

Spermaceti candles are of modern manufacture: they are made smooth, with a fine gloss, free from rings and scars, superior to the finest wax candles, in colour and lustre; and, when genuine, leave no spot or stain on the finest silk, cloth, or linen.

In the Transactions of the Royal Society of London, there is a treatise on the conversion of animal muscle, into a substance much resembling spermaceti. It appears from a number of experiments, that if flesh is exposed to the action of water for a considerable time, it will change it into a fatty substance; which discovery might be applied to profit, for making grease or fat for many purposes. The nitrous acid greatly accelerates this transformation, and takes away the offensive putrid smell. By submitting it to the action of the oxygenated muriatic acid, the fermentation goes on more slowly, but it may be procured quite white and pure.

SPINNING. Spinning is applied to the reducing of silk, flax, hemp, wool, hair, &c. into thread, and is usually performed by women.

Spinning by hand is performed either with the distaff and spindle, or on the wheel: in the former case the person sits to her work; in the latter she stands, or rather runs backwards and forwards. We shall describe both methods. When the distaff and spindle are used, the flax or other substance is tied or fixed on a long stick: the spinner draws out a thread, which she fixes to her spindle; then with her left hand she turns the wheel, and with her right guides the thread drawn from the flax, &c. round the spindle, or rather round a spool which goes on the spindle. When a sufficient quantity is wound on the spool, it is taken off, thrown into the basket, and replaced by an empty one.

Spinning of wool is managed by a different process. Here the wool, in those fine slivers taken from the wool-comber, is held in the hand; a thread of it is fastened to the wheel, which the spinner turns with velocity, and runs backward from it, thereby drawing out the thread to a considerable length. In either mode of spinning, when the spindle is filled, its thread is wound upon a reel, and taken off, in the form of a skain or hank. The wool is delivered out to the spinner by weight, and when she returns it, it is again weighed.

Besides the above mode of spinning wool upon the wheel, a more ancient method is still practised with the distaff and spindle, which may be used either sitting or walking, while the spinner tends on cows, poultry, &c. The sliver of wool is braided round the distaff (or rock as it is called;) from the slit end of which a thread is drawn and fastened to the slender spindle, which receives a whirling motion by being quickly rolled, upon a piece of smooth leather called the trip-skin, fastened upon the thigh of the spinner, who with one hand gently draws a few hairs from the tail of the sliver, while the other winds up the spindle, and renews its whirling motion. In this way finer yarn is made, than by any other method, but more than six pence a day can seldom be earned.

Spinners are employed by the master wool-combers. Spinning the wool into skains is the first process: these are afterwards put into the hands of other women, called winders, whose business is, by means of a wheel and other simple apparatus, to wind two, three, or more of these skains together, so as to make a compound thread of them. This thread is wound on to spools or bobbins, for the convenience of having them fixed on spindles, which are turned round by mill-work, in order to twist the threads thus combined into a firm substance. When taken from the mill, the worsted is washed, dyed, and dried; it is then done up in crewels, and fit for sale.

The variety and importance of those branches of manufactures which are produced from cotton, wool, and flax, spun into yarn, have occasioned many attempts to render spinning more easy, cheap, and expeditious, by means of complicated machinery. Several of these have been

very successful; particularly those for cotton, by sir Richard Arkwright; but the spinning-mill has not as yet been able, to afford worsted yarn so cheap as that which is spun by hand.

Mr. Antis, of Fulneck, near Leeds, in 1793, says Dr. Willich, submitted to the inspection of the *Society for the Encouragement of Arts*, &c. a model of an improved spinning-wheel; for which they conferred on him a bounty of 20 guineas.

The usual method of stopping the wheel, with a view to remove the yarn from one staple on the flyer to another, necessarily occasions great loss of time; but, in Mr. Antis's contrivance, the bobbin is so arranged, as to pass backward and forward, in order to prevent any interruption; and at the same time, to obviate both the breaking of the thread, and losing the end: hence the spinner is enabled to perform more work, in a given time, than is practicable by any other spinning-wheel. Such object is effected, by extending the axis of the great wheel through the pillar next the person spinning; and forming it into a pinion of one leaf, which catches into a wheel, seven inches in diameter, having on its periphery 97 teeth; so that 97 revolutions of the great wheel, require only one of the smaller wheel. On the latter, a wire-ring is fixed: which being supported on six legs, stands obliquely to the wheel itself; touching it at one part, and projecting nearly three quarters of an inch at the opposite edge. Near the side of this wheel, is an upright lever, about fifteen inches in length, moving on a centre, three inches from its lower extremity, and connected at the top with a sliding bar. From such bar rises an upright piece of brass, which works in the notch of a pully, and drives the bobbin to and fro, during the revolution of the wheel.

In order to regulate and assist the alternate motion, a weight is suspended by a line from the sliding-bar; and passing over a pulley, it rises or falls, as the bobbin advances or recedes; tending constantly to keep the pin in contact with the wire. In consequence of this construction, the flyer requires only one staple; which, being fixed near its extremity, the thread entering through, is regularly laid on the bobbin, by the rotatory motion of the latter.

Since Mr. Antis presented the model of the machine here described, he has made several alterations, which greatly contribute to its perfection; and for which the Society in 1795, rewarded him with the additional sum of fifteen guineas. As we conceive, that an account of these improvements will be interesting to every industrious house-wife, we shall concisely state them, together with Mr. Antis's remarks.

1. At every revolution of the wheel, in his former machine, the pinion with one leaf occasioned a very disagreeable catch, while the bobbin moved only by jerks, and did not receive the thread in an uniform manner. With a view to remedy this inconvenience, Mr. Antis has adopted the motion of an endless screw, working a toothed wheel, on which is fixed a heart-shaped piece of brass.

2. As the spinner should always be enabled to hold the thread at pleasure, and not let it in, till it be sufficiently twisted, Mr. Antis observed, that, the bobbin moving on a square, its motion was so impeded, that when it began to be filled with thread, it became immoveable, notwithstanding the action of the weight; and when the thread was afterwards left at liberty, it started at once half an inch and upwards.

3. As in the wheels of the common construction, and also in those of Mr. Antis's first improvement, the friction of the bobbin could be augmented, only by stretching the common cord, which was not practicable, without making the wheel revolve, with increasing difficulty, particularly when the bobbin was nearly filled; he was induced to make use of a single cord, the sole design of which is to turn the flyer; and, in case it should become slack, it may be contracted or shortened, without requiring any screw.

Farther, to regulate the friction of the bobbin, Mr. Antis has fastened a neck of steel, or brass to one end, which is kept steady by a vice, or by pincers, fixed to the sliding-bar. Such vice is directed to be made either of two elastic springs, furnished with wooden tops; or wholly of wood bushed with leather, and provided with a spring, under the shoulder of the screw, to answer the same purpose. By tightening this screw to a greater or less degree, the friction may be most accurately regulated, without impeding the velocity of the whole; as no additional machinery obstructs the general motion. Mr. Antis, therefore, concludes, that a wheel, on this improved plan, will be found to run more freely than those with a double cord; a circumstance of the greatest importance, to a person whose daily livelihood is obtained by spinning: nay, even a lady who sometimes spins for her diversion, was much pleased with his first invention, and thought it might save a person at least two hours in a day. He observes, that his contrivance may be added to old spinning wheels, of

every construction; and that it would not considerably increase the price of a new machine, made according to his plan.

It would take up too much of our work, to give an explanation of the various improvements of Mr. Arkwright, in spinning machinery: some of which, however, have been given in the article on MANUFACTURES. The subject has been much attended to in this country, and been productive of considerable advantages; for labour-saving machinery, especially when labour is high, will always be useful in a country like this.

We might enumerate the names of many, who, with patriotism and zeal for the encouragement of manufactures, have added considerably to this important endeavour. Spinning machinery either to go by hand, water or other power, to turn from ten to a thousand spindles, have been erected in almost every quarter of the union. The portable machine of J. G. Baxter, which may be seen at No. 5, Apple-tree alley, belonging to the Female Hospitable Society, Philadelphia, which works by hand, will turn from ten spindles to any number found necessary. That of Dr. Allison of Bordentown, New-Jersey, is highly approved; and the late and lamented J. Beers, Esq. of Holmesville, Bucks county, Pennsylvania, who improved spinning machinery very considerably, and was well known as a manufacturer, is among the number to whom our country is most indebted. The spinning machinery of Craig & Marquedant, erected in the vicinity of this city, which gives employment in the different branches of the work, to a large number of females, also exhibits the genius and zeal of our countrymen. See MANUFACTURE OF COTTON.

SPIRIT.—This name was formerly given by chemists to all volatile substances collected by distillation. Three principal kinds were distinguished: inflammable or ardent spirits, acid spirits, and alkaline spirits. In the first class were included not only the product known by the common name of spirit of wine, and its compounds, but the light volatile oils, ethers, and the aromatic principle. The subjects of the latter class need no enumeration.

The word spirit is now almost exclusively confined to alcohol; and the other substances formerly arranged under the classes here mentioned, are distinguished respectively by their peculiar names, without reference to any general arrangement grounded on a property of so indistinct a nature as that of their being separated from other bodies by distillation. See ALCOHOL.

Spirit may be produced from a variety of substances, after fermentation, by distillation; such spirits are said to be distilled. Fruits, roots, and vegetables of various kinds, principally such as contain much saccharine matter, in which the United States abound, are employed in this country for the purpose. What is called apple brandy, or cyder spirits, of which some notice has already been taken, is made in considerable quantities. The apples are mostly taken to the distillery, where they are exchanged for spirit, in the proportion of five bushels to one gallon of liquor. The apples are operated on and expressed, in the usual manner; the cyder is afterwards fermented in large cisterns, or vats, and in 6 or 8 days, according to the weather, is fit for the still. The pumice, after expression, is preserved in some distilleries, where it is treated with water, fermented, the liquor pressed out, and distilled. In Lancaster county, in this state, it is customary to grind the apples, ferment the pumice thus formed, and commit the whole to distillation. Some difference is said to be made in the spirit obtained from apples; one kind is called apple brandy, and the other apple spirit, which distinction, however, is seldom made, the whole being sold as apple whiskey. The spirit obtained from peaches, which is done in the same manner as apples are treated, is called peach liquor, or peach brandy. This spirit is said to be improved by bruising the kernels, and distilling them with the fermented juice.

Cherries and fox-grapes, expressed, and the juice fermented and distilled, will afford agreeable liquor. The former, however, are more generally made into a liquor called bounce. The latter, if properly treated, yield a spirit not inferior to Cogniac brandy. To imitate this, let them be mashed, and after standing a day or two, the juice must be expressed and fermented as with peaches, and the fermented liquor then distilled. From potatoes a spirit is obtained of a good quality. According to Bertrand, 600 lbs. of potatoes are boiled, and reduced to a mash with hot water, till they are of a liquid consistence, and mixed with 25 lbs. of ground malt, and two quarts of yeast; the mixture is to be stirred, covered with a cloth, and kept to the temperature of 66° of Fahrenheit. After fermentation, the matter sinks down, and is fit for distillation. Two stills will distil this matter in one day; and the spirit produced will amount to 44 quarts. The residue is fit for hogs. The process for procuring spirit from potatoes has been more or less varied.

Beets, as they afford much sugar, will also produce much spirit by fermentation and distillation. The distillation of fermented beet roots has not, however, been yet attempted. In France, sugar is obtained from them.

An union of rye and corn in mashing, will, it is said, produce more spirit than can be procured from either grain alone. Corn is seldom, if ever, used alone. Wheat, although not used, will yield more spirit than rye, in the proportion of six to five

Three gallons of spirits may be procured from 60 lbs. of oats; but a mixture of one-third of oats, and two-thirds of corn, will afford a better liquor. Other grains will yield spirit in different proportions, and more or less good. See ALCOHOL, GIN, BRANDY, DISTILLATION, &c.

SPIRIT OF WINE. See ALCOHOL.

SPIRITUOUS LIQUORS, to try. See ALCOHOL and HYDROMETER.

SPIRIT OF NITRE. See NITRIC ACID.

SPIRIT OF SALT. See MURIATIC ACID.

SPIKE OIL. See OIL.

SPRUCE, *Essence of*, is an extract prepared from the canes, twigs, or sprouts, of the spruce fir. It is used only in preparing beer, according to the following process:

SPRUCE BEER, *to make.*—Eight gallons of water are first poured into a cask, or other vessel; and a similar quantity of boiling water is added; 16 lbs. of molasses are next mixed, together with a few table-spoonfuls of the *essence of spruce*. Half a pint of sweet yeast must now be put in; and the whole, after being well stirred, should be placed in a temperate room, for a few days, till the fermentation ceases. The liquor may then be bottled; and, in the course of a fortnight, it will be fit for use.

This process is varied sometimes. The following receipt is said to be preferable.

To a four ounce pot of essence of spruce, add three quarts of molasses, two gallons of warm rain or soft-water, and half a pint of good yeast. Stir the whole well, till the liquor bears a froth, then put the mixture into a cask, and fill it with eight gallons of water, shaking it well; set it by for two or three days, to ferment, with the bung open; when sufficiently worked, bung the cask close, and place it in a cool cellar, and in 24 hours it will be fit for use....If intended for bottling, let the cask stand undisturbed three days before it is drawn off: for a second brewing, the sediment remaining in the cask may be used instead of yeast. If well-water be used, it should be a little warmed.

The Dantzig spruce beer is reckoned the best; the taste of the American spruce is less agreeable.

SPUR WHEEL. See MECHANICS.

STAINS, *how removed.—To remove ink stains*....The stains of ink on cloth, paper, or wood, may be removed by almost all acids; but those acids are to be preferred which are least likely to injure the texture of the stained substance. The muriatic acid, diluted with five or six times its weight of water, may be applied to the spot, and, after a minute or two, may be washed off, repeating the application as often as may be found necessary. But the vegetable acids are attended with less risk, and are equally effectual. A solution of the oxalic, citric (acid of lemons), or tartareous acids, in water, may be applied to the most delicate fabrics without any danger of injuring them; and the same solutions will discharge writing, but not printing ink. Hence they may be employed in cleaning books which have been defaced by writing on the margin, without impairing the text. Lemon-juice, and the juice of sorrels, will also remove ink stains, but not so easily as the concrete acid of lemons or citric acid.

To remove Iron Stains.

These may be occasioned either by ink stains, which, on the application of the soap, are changed into iron stains, or by the direct contact of rusted iron. They may be removed by diluted muriatic acid, or by one of the vegetable acids already mentioned. When suffered to remain long on cloth, they become extremely difficult to take out, because the iron, by repeated moistening with water, and exposure to the air, acquires such an addition of oxigen, as renders it insoluble in acids. It has been found, however, that even these spots may be discharged, by applying first a solution of an alkaline sulphuret, which must be well washed from the cloth, and afterwards a liquid acid. The sulphuret, in this case, extracts part of the oxigen from the iron, and renders it soluble in diluted acids.

To remove the Stains of Fruit and Wine.

These are best removed by a watery solution of the oxigenated muriatic acid, or by that of oxigenated muriat of potash or lime, to which a little sulphuric acid has been added. The stained spot may be steeped in one of these solutions till it is discharged; but the solution can only be applied with safety to white goods, because the uncombined oxigenated acid

discharges all printed and dyed colours. A convenient mode of applying the oxigenated acid, easily practicable by persons who have not the apparatus for saturating water with the gas, is as follows: Put about a table-spoonful of muriatic acid (spirit of salt) into a tea-cup, and add to it about a tea spoonful of powdered manganese; then set this cup in a larger one filled with hot-water; moisten the stained spot with water, and expose it to the fumes that arise from the tea-cup. If the exposure be continued a sufficient length of time, the stain will disappear.

To remove Spots of Grease from Cloth.

Spots of grease may be removed by a diluted solution of potash, but this must be cautiously applied, to prevent injury to the cloth. Stains of white wax, which sometimes fall upon the clothes from wax candles, are removable by spirits of turpentine, or sulphuric ether. The marks of white paint may also be discharged by the last mentioned agents.

To take Spots of Grease out of Books, Prints, or Paper.

After having gently warmed the paper that is stained with grease, wax, oil, or any other fat body, take out as much as possible of it by means of blotting paper; then dip a small brush in the essential oil of turpentine, heated almost to ebullition (for when cold it acts only very weakly), and draw it gently over both sides of the paper, which must be carefully kept warm. This operation must be repeated as many times as the quantity of the fat body imbibed by the paper, or the thickness of the paper, may render necessary. When the greasy substance is entirely removed, recourse may be had to the following method to restore the paper to its former whiteness, which is not completely restored by the first process. Dip another brush in highly rectified spirit of wine, and draw it in like manner over the place which was stained, and particularly round the edges, to remove the border that would still present a stain. By employing these means with proper caution, the spot will totally disappear, the paper will resume its original whiteness, and if the process has been employed on a part written on with common ink, or printed with printers ink, it will experience no alteration.

STAINING OF WOOD, *how performed.* See Dyeing.

STARCH.—We shall in this place mention the mode of manufacturing the common starch which is made, for sale, almost exclusively from wheat. This grain consists of gluten, fecula, a colouring extractive matter, and phosphat of lime, and it is the object of the starch-maker, to separate the fecula alone from all the other ingredients. This might be done, one would think, simply, as the arrow root starch is made in the West Indies, by grinding the wheat into very fine flour, mixing the flour with water into a stiff paste with much beating, and then exposing this paste with uninterrupted agitation to a gentle current of pure water, which would run off milky with the starch as long as any of it remained in the paste, and the gluten alone would be left behind. This milky water would deposit the starch by remaining at rest for a time.

A similar method is followed in the small way in making potatoe starch, as mentioned under the article *fecula*, only with less labour, as this contains no gluten.

Wheat starch is not made, however, exactly in this simple way, but the grain, after being coarsely ground, is suffered to ferment or mould with water for many days, by which its texture is entirely broken down, and the starch, which is scarcely alterable in the process, is probably more effectually separated from all the other ingredients, and obtained finer and whiter. The actual method is (in a few words) the following: The wheat is first coarsely bruised, and placed in large wooden vats or reservoirs, water-tight, and intimately mixed with water. Here a fermentation begins after a time, which is a mixture of the vinous and acetous, and is attended with a strong, unpleasant, sour, mouldy smell. The wheat remains in the vat for about a fortnight, till the fermentation ceases, which is known by its settling at the bottom of the vat. The contents are then emptied successively into a small tub, and mixed with fresh water, till all the pulpy part is thin enough to pass through a hair sieve, which separates the bran from it. What has gone through contains the starch suspended in a very sour water, and considerably foul. This is put into tubs or frames, and allowed to remain for two days undisturbed, during which the impure starch settles to the bottom. The water is then drawn off, the frames turned on their sides, and the dirty discoloured part of the starch (which is the last that subsides, and therefore is at the top) is scraped off, and the remaining starch is well washed and brushed, till it is nearly free from this muddy sediment, which is called *slimes*, and is treated separately to obtain its starch. The starch is stirred with fresh water, and suffered to settle, and

again cleansed, till all its impurities are removed, and is then mixed with water enough to make it liquid, and passed through a fine lawn sieve. It is then fit to receive its colour, which consists of smalt mixed with water and a small quantity of alum, and is thoroughly incorporated with the starch. After again settling, the starch is taken out and put into oblong boxes, about six feet long and one broad, with holes at the bottom, and lined with linen cloth, where the moisture of the starch drains off till it becomes solid enough to be cut into square lumps. These are laid on new bricks, which absorb much of their moisture, and make them hard enough to be stoved. Here the starch remains in a moderate heat, till a slimy crust rises to the surface, which is carefully scraped off, and the rest, which is now perfectly pure starch, is papered and placed again in the stove with a good hot fire, till quite dry. This last stoving causes the lumps to crack pretty uniformly into the small pieces in which they appear when sold. The *slimes* are all treated in the same way till all the starch is got from them. All the refuse matter from starch making makes very valuable food for fattening hogs. The whole time of making starch, from the first steeping of the wheat to the last stoving, is about six weeks; and 551 Winchester bushels of wheat will make about six ton of starch. This will be about 7-17 of the entire weight of the wheat.

In the process of starch-making a great quantity of a sour nauseous milky water is obtained, from which the starch subsides after it is first removed from the fermenting vat.

The starch-sours contain, besides a visible white matter separable by filtering, a quantity of phosphat of lime and ammonia, both held in solution by the acetous acid which is generated so abundantly by the fermentation. A peculiar animal matter is also found in this acid liquor, which seems to resemble *gluten*, and therefore only belongs to that starch which is made from wheat flour.

This liquor therefore contains the five following substances, viz. acetous acid, ammonia, alcohol, gluten, and phosphat of lime, but of these only the two last are natural to the wheat; the others are the products of the fermentation, the ammonia being generated by the decomposition of part of the gluten, the alcohol by the saccharine mucilage which all grain contains, and the acetous acid perhaps from all the other principles. The peculiar office which this acid performs in starch-making is to dissolve the gluten and phosphat of lime, and thus to separate them from the pure starch. Hence, when wheat is the grain employed, arises the necessity of continuing the fermentation long enough to generate a sufficient quantity of acetous acid; for the other grains and roots which yield starch, contain little or no gluten. A considerable quantity, however, of the starch must be destroyed in the process, for wheat contains much more of it than is obtained in manufacture, as may be found by washing flour paste with water in the way mentioned in the beginning of this article.

According to Parmentier, the roots of twenty-two vegetables yield starch, and the seeds of nine plants and trees contain it nearly pure. The Indian turnip also produces it. Dry mealy potatoes afford a large proportion of starch. Baume gives the following method:

Take *clean mashed* potatoes, collect the pulp in a tub, and mix it with a great quantity of *clean* water. Place two wooden rails on the brim of another *very clean* tub to support a sieve, which must not be too fine. Throw the pulp and water into the sieve; pour fresh quantities of water on the pulp, till the clear water runs through. In six hours the water will have deposited the flour suspended in it; when the water is to be poured off, and a great quantity of very *clean* water poured upon the flour remaining at the bottom of the tub, which is to be stirred up in the water, and the whole is to stand quiet till the day following. The flour will then be found to have settled at the bottom of the tub: the water is again to be poured off; the flour washed in a fresh quantity of pure water, and the mixture passed through a silk sieve pretty fine. The whole must once more be suffered to stand quiet till the flour is settled, if the water above it is clean, and the flour has been sufficiently washed; but if the water has any colour, it must be again washed.

When perfectly washed, take out the flour, and place it upon wicker frames covered with paper, and dry it, properly defending it from the dust. When dried, pass it through silk sieves, to divide any clotted lumps that may remain; and keep it in glass vessels stopped with paper only.

The following is the method adopted by a Mrs. Gibbs, for preparing starch from the roots of the Wake-Robin; for which the Society for the Encouragement of Arts, &c. in 1797, presented her with their gold medal. She observes, in her communication, that such roots are found in the Isle of Portland, in the common

fields, whence they may be dug out, cleansed, and pounded in a stone mortar with water. The whole is then strained, and the starch settles at the bottom: a peck of these roots produced, upon an average, about four pounds of starch, which was sold at 11d per pound.

Good starch, when dry, is pulverulent, tasteless, without odour, insoluble both in cold water and ardent spirit: on the addition of boiling water, however, it forms *Paste*, or *Pastry*, of which the reader will find an account. ..It is one of the constituent parts in all mealy or farinaceous seeds, fruits, roots, &c. of plants; though some vegetables contain a much larger proportion of it than others. Thus, the Wake-Robin, and White Bryony, afford more starch than potatoes; and the Salep-roots, especially those of the Meadow-Orchis, for the greatest part, consist of that valuable substance.

Starch being the basis of *hair-powder*, and also of extensive utility for domestic purposes, various experiments have been instituted, with a view to ascertain such vegetables as might be advantageously substituted for wheat.

STATERA, ROMAN. See MECHANICS

STEAM, is water in the state of vapour, produced by ebullition, or a temperature of 212 degrees of heat. It is applied to various purposes, and is more particularly useful as a moving power, in what is called the steam engine. The conversion of water into steam is owing to its combination with the matter of heat, and that of steam to the state of water to the abstraction of heat by a colder medium.

Steam may be employed in domestic economy, and particularly in cooking. Thus, *steamed* potatoes are always more wholesome and nutritious, than such as are boiled in water; and Dr. Darwin observes, that if the heat of the steam could be increased after it has left the water, the art of boiling all vegetables might be considerably improved; and thus the mucilage, abounding both in potatoes and flour puddings, and also in the roots, seeds, stems, leaves, and flower-cups of plants, may be rendered more nutritive, and, probably, more palatable. See STEAM ENGINE.

STEAM DISH.—This very useful contrivance is described in the Repertory of Arts, vol. 4, and in the Domestic Encyclopedia, vol. 5. It is made of tin, or earthenware, (for a family of six or eight) twelve inches by nine, at the top, and nine by seven, at the bottom, four and a half inches deep, on the slant rim, and three inches, in the clear, under four resting knobs, (a little below the top,) which space is to be occupied by the meat of which the pastry is made.

STEAM STOVE.—In a late improvement made to the common stove, by Mr. Abbot of this city, a tin vessel may be so applied as to boil or bake by means of steam. This stove is indeed superior to all others, as it may be used for boiling, baking, &c. at the same time, and consumes a less quantity of fuel. The price is from $30 to $35, according to the size.

STEAM ENGINE.—The steam engine is one of the noblest monuments of human ingenuity. It was originally invented by the Marquis of Worcester, in the reign of Charles II. This nobleman, who appears to have been possessed of much knowledge, with a fertile imagination, published in 1663, a small book, called "A Century of Inventions," giving an account of an hundred discoveries or contrivances of his own; but the descriptions of many of them are so obscure, that they are altogether unintelligible.

Among them is an account of his invention of raising water by the force of steam, which, now that we are possessed of the engine, appears to agree very well with its construction. But as there is no plate to accompany his description, we are entirely unacquainted with the particular mode in which he applied the power of steam. It does not appear, however, that he met with sufficient encouragement; and this useful discovery was long neglected.

Towards the end of the century. Captain Savary, a person of great ingenuity, having probably seen the account of the Marquis of Worcester's invention, was convinced of its practicability, and succeeded in constructing a machine of this kind He obtained a patent for the invention, and erected several steam engines, which he described in a book, entitled, "The Miner's Friend," published in 1696.

The following is the description of his machine, as improved by himself:

a (Plate XVIII, fig 1.) is a strong boiler, built in a furnace for generating steam. From the top of this boiler there proceeds a pipe, *b*, which conveys the steam into another strong vessel, *r*, called the *receiver* This pipe has a cock at *c*, called the *steam-cock*. In the bottom of the receiver is a pipe, S, which communicates with the rising-pipe H *n k*, the lower end of which is immersed in the well from which the water is to be raised. Immediately below the place where the pipe S enters the rising-pipe, there is a valve, *n*, opening upwards. A similar valve is also

placed at i, above the pipe S. Lastly, there is a pipe, e, which branching off from the rising-pipe, enters the top of the receiver. This pipe has also a cock, d, called the *injection-cock*. The mouth of the pipe e, has on the end f a nozzle, pierced full of holes, pointing from a centre in every direction. The keys of the two cocks c and d, are united by the handle h, called the *regulator*.

The mode of operation is as follows: Let the regulator be so placed, that the steam-cock c be open, and the injection-cock d shut; put water into the boiler a, and make it boil. The steam from it will enter the pipe b, and fill the receiver, first driving out the air which it before contained; a considerable quantity of steam will be at first condensed by the cold sides of the receiver, but it being at length warmed, the steam will proceed into the rising-pipe, lifting up the valve i. When this is perceived to be the case, by the rising-pipe feeling warm, and hearing the valve i rattle, the communication is now to be cut off from the boiler, by shutting the steam-cock c, the injection-cock d, being also shut. The receiver now gradually cools, and the steam included in it condenses into water. When this is the case, as the air was at first driven out by the steam, and cannot return again, all the cocks being shut, a vacuum is formed in the receiver; consequently, there is nothing to counterbalance the pressure of the atmosphere, which acting upon the water in the well, forces it up the rising-pipe, and fills the receiver. The steam-cock is now opened; and the steam from the boiler rushing in with great violence, presses upon the surface of the water in the receiver, and forcing it through the pipe s, into the rising-pipe, causes it to shut the valve n, and open the other valve i; and, provided the steam be sufficiently strong, will force it up the rising-pipe to the top k, where it is delivered. The cock c is kept open until all the water be driven out of the receiver, and it is again filled with steam. The regulator is now applied, which shuts the steam-cock, whilst at the same time it opens the injection-cock. The rising-pipe being still full of water, a stream of cold water proceeds through the pipe c, and enters the receiver in a shower. This instantly condenses the steam in the receiver, and produces a vacuum as before; in consequence of which, the water from the well is again forced up by the external pressure of the atmosphere, and the receiver is again filled with water. The regulator is then turned, which shuts the injection-cock and opens the steam-cock, which permits the steam from the boiler to press upon the water, and again force it up the rising-pipe. This operation filling the receiver with water by means of a vacuum produced in it, and forcing it up the rising-pipe by the pressure of the steam from the boiler, is constantly repeated, by merely turning the regulator, which shuts and opens the steam-cocks and injection-cocks alternately.

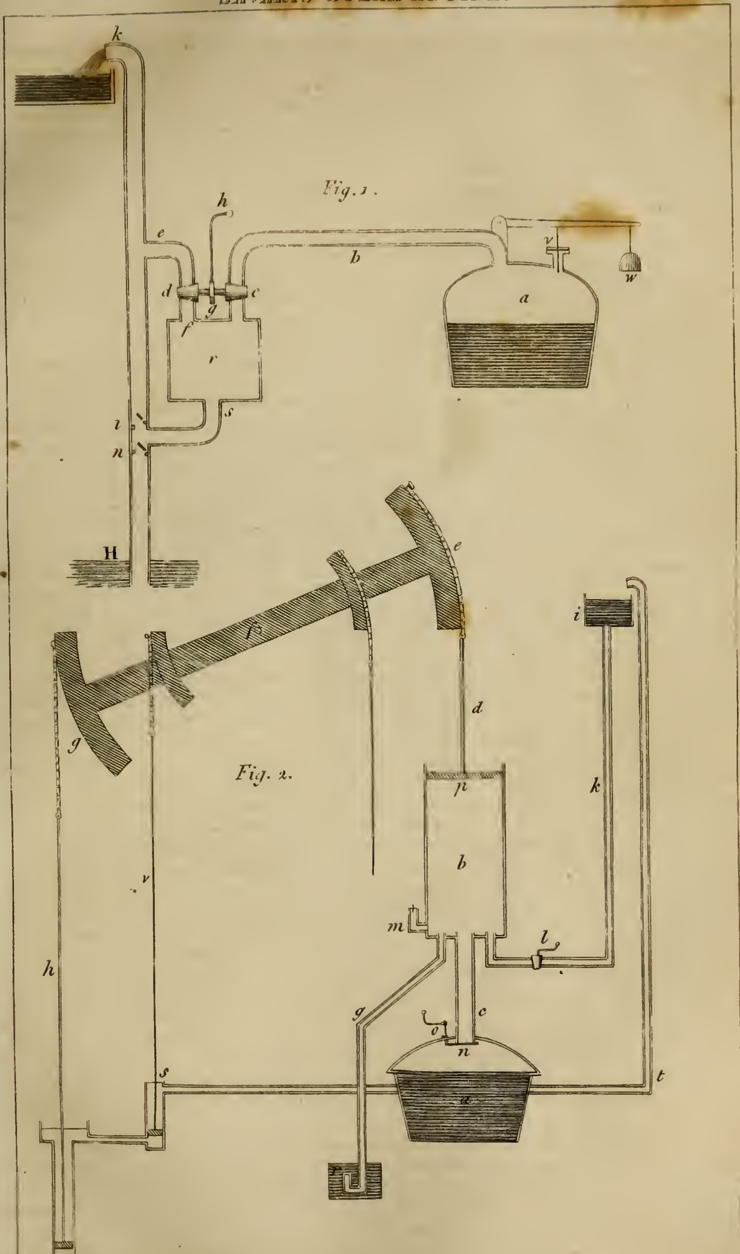
This construction of the steam engine is extremely simple, and might perhaps be successfully applied for some purposes. But it has several considerable defects. It may readily be apprehended, that the action of the direct steam on any definite surface, such, for example, as a square inch, will be accurately equal to the reaction of the water which is forced up; and consequently, that Savary's engine will require steam more elastic than the air of the atmosphere, in every case except where the water is raised no higher than it can be by the vacuum that is produced, and the pressure of the atmosphere.

When the water is forced up through the rising-pipe, every square inch of the boiler must sustain a pressure equal to a column of water an inch square, and of the height of the pipe above the boiler. This, therefore, requires very strong vessels, and several accidents have happened by their bursting when the safety valve was loaded too much.

But the greatest defect of this machine is the great waste of steam, and consequently of fuel. For when the steam is admitted to the top of the cold water in the receiver, it is condensed with great rapidity; and the water does not begin to yield to its pressure, until its surface be so hot, as not to condense any more steam. It now descends, but as by that, a new part of the side of the receiver is exposed to the steam, more is condensed, so that a condensation of the steam is going on all the while the water is descending. This too, must necessarily be repeated every stroke, as the receiver is cooled every time it is filled with water.

Mr. Savary succeeded in raising water to small heights, and erected several engines in different parts of England; but he could make nothing of deep mines. Many attempts have been made to correct these defects, but hitherto without much success.

In the beginning of the eighteenth century, Newcomen, an ironmonger or smith, and Cauly, a glazier at Dartmouth, in Devonshire, in England, first conceived the project of applying a piston with a lever, and other machinery. They were contented to share the profits of the invention with



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Savary, who procured a patent for it in 1705, in which they were all three joined.

Fig. 2, exhibits a section of Newcomen's engine: *a* is the boiler, built in brick-work. In the top of the boiler is a steam-pipe, *c*, communicating with the cylinder *b*, which is of metal, and is bored very truly. The lower aperture of this pipe is shut by the plate *n*, which is ground very flat, so as to apply very accurately to the whole circumference of the orifice. This plate is called the regulator or steam-cock, and it turns horizontally round an axis, *o*, which passes through the top of the boiler, and is fitted by grinding to the socket, so as to be steam-tight. It is opened and shut by a handle fixed to its axis.

In the cylinder *b*, is a solid piston *p*, well fitted into it, and made air-tight by a packing of leather or soft rope, well filled with tallow, and for greater security, a small quantity of water is kept above the piston.

The piston-rod *d* is suspended by a chain, which is fixed to the upper extremity of the arched head *e* of the great lever or *working-beam*, *e f g*, which turns on the gudgeon *f*. There is a smilar arched head *g*, at the other end of the beam, to the upper extremity of which is fixed a chain, carrying the pump-rod *h*, which raises the water from the mine.

The load on this end of the beam is made to exceed considerably the weight of the piston at the other extremity.

At a small height above the top of the cylinder, is a cistern called the *injection-cistern*, *i*. From this descends the *injection-pipe*, *k*, which enters the bottom of the cylinder, and terminates in a nozzle pierced with holes. This pipe has a cock, *l*, called the *injection-cock*.

At the opposite side of the cylinder, a little above its bottom, there is a lateral pipe, *m*, turning upwards at the extremity, and there covered by a clack-valve, called the *snifting-valve*, which has a little dish round it, to hold water for keeping it air-tight.

There proceeds also from the bottom of the cylinder, a pipe *g*, of which the lower end is turned upwards, and is covered with a valve *r*. This part is immersed in a cistern of water, called the hot-well, and the pipe itself is called the *eduction-pipe*.

Lastly, the boiler is furnished with a safety-valve, called the *puppet-clack*, in the same manner as in Savary's engine. This valve is generally loaded with one or two pounds in the square inch, so that it allows the steam to escape when its elasticity is one-tenth greater than that of the atmosphere. Thus all risk of bursting the boiler is avoided, the pressure outwards being very moderate.

When the cistern for the injection water *i*, cannot be supplied by pipes from some more elevated source, water is raised by the machine itself. A small lifting-pump, *s*, is worked by a rod, *r*, suspended from a small arch upon the great beam; this forces water through the pipe *t*, into the injection-cistern.

The parts of the engine being now described, the operation is as follows:

Suppose the piston and lever in the position represented in the plate, and the water in the boiler in a state of ebullition, the steam and injection-cocks being shut. Having opened the steam-cock, *n*, the steam from the boiler will immediately rush in, and flying all over the cylinder, will mix with the air.

Much of it will be condensed by the cold surface of the cylinder and piston, and the water produced from it will trickle down the sides, and run off by the eduction-pipe. This condensation, and waste of steam, will go on until the whole cylinder and piston be made as hot as boiling water.

When this happens, the steam will begin to issue through the snifting valve, slowly at first, and cloudy, being mixed with much air; but, by degrees, it will become more transparent, having carried off the greatest part of the air which filled the cylinder.

When the attendant perceives that the blast at the snifting-valve is strong and steady, and the boiler is supplied with steam of a proper strength, appearing by the renewal of its discharge at the safety valve, which had stopped while the cylinder was filling, he shuts the steam-cock, *n*, and opens the injection-cock, *l*. The pressure of water in the injection-pipe forces some out into the cylinder, which condenses the steam and forms a partial vacuum, as explained above

The upper side of the piston is now exposed to the whole pressure of the atmosphere, which not being counterbalanced on the under side, will act with its whole force on the piston, and, provided there be not too much weight on the other end, will raise it, the piston going to the bottom of the cylinder.

When the piston has gone down as low as necessary, the injection-cock is shut, and the steam-cock opened. The steam, which has been accumulating above the water in the boiler, during the time of the descent of the piston, and is now issuing

through the puppet-clack, as soon as the steam-cock is opened, rushes violently into the cylinder, having a greater elasticity than that of the air. It therefore immediately blows open the snifting-valve, through which it drives out the air that had been disengaged from the injection-water.

At the same time, the water which had been injected before, and the condensed steam, run out through the eduction-pipe *q*, and lifting up the valve *r*, flow into the hot-well.

By the admission of the steam under the piston, the pressure of the atmosphere on the top is counterbalanced, and the piston is free to move upwards or downwards.

But the other end of the beam being broader, so as to be heavier than the piston, now raises it to the top of the cylinder, whence it is again forced downwards by the pressure of the atmosphere, as soon as a vacuum is formed under it by the admission of the injection-water. In this manner the operation is repeated; the piston being forced down by the weight of the atmosphere, raises the other end of the beam, with whatever is attached to it; and, on the other hand, when the pressure of the atmosphere is counterbalanced by the steam under the piston, the superior weight of the pump-end of the beam brings the piston up again.

We now see the difference between Savary's and Newcomen's engine, in respect to principle. Savary's was an engine that raised water by the force of steam; but Newcomen's raises water entirely by the pressure of the atmosphere, and the steam is employed merely as the most expeditious mode of producing a vacuum, into which the atmospherical pressure may impel the *first mover* of his machine.

We see also the great superiority of this new machine. We have no need of steam of great and dangerous elasticity; and we operate by means of very moderate heats, and consequently with much smaller quantity of fuel; and there are no bounds to the power of this machine. How deep soever a mine may be, a cylinder may be employed of such dimensions, that the pressure of the air may exceed, in any degree, the weight of the column of water to be raised. And lastly, this form of the machine renders it applicable to almost every mechanical purpose; because a skilful mechanic can readily find a method of converting the reciprocating motion of the working beam into a motion of any kind which may suit his purpose. Savary's engine could hardly admit of such a general application, and seems almost restricted to raising water.

Inventions improve by degrees. Newcomen's engine was first offered to the public in 1705. But many difficulties occurred in the execution of it, which were removed one by one; and it was not till 1712, that the engine seemed to give confidence in its efficacy.

The most exact and unremitting attention was required, to open and shut the cocks precisely at the proper time; for neglect might be ruinous to the machine, by the confined steam beating out the bottom of the cylinder, or allowing the piston to be wholly drawn out of it. Stops were contrived to prevent these accidents; then strings were used to connect the handles of the cocks with the beam, so that they should be turned whenever it was in certain positions. These were gradually changed, and improved into detents, and catches of different shapes; at last Mr. Beighton, a very ingenious and well informed artist, simplified the whole of these subordinate movements, and otherwise very much improved this machine.

The greatest improvement that has since been made on Newcomen's engine, has been in the manner of placing the boiler. Instead of placing it underneath the cylinder, it is built at some distance from it, and sometimes in a separate building.

About 1762, Mr. Watt began to turn his attention to this machine, which he has since brought to so great a degree of perfection.

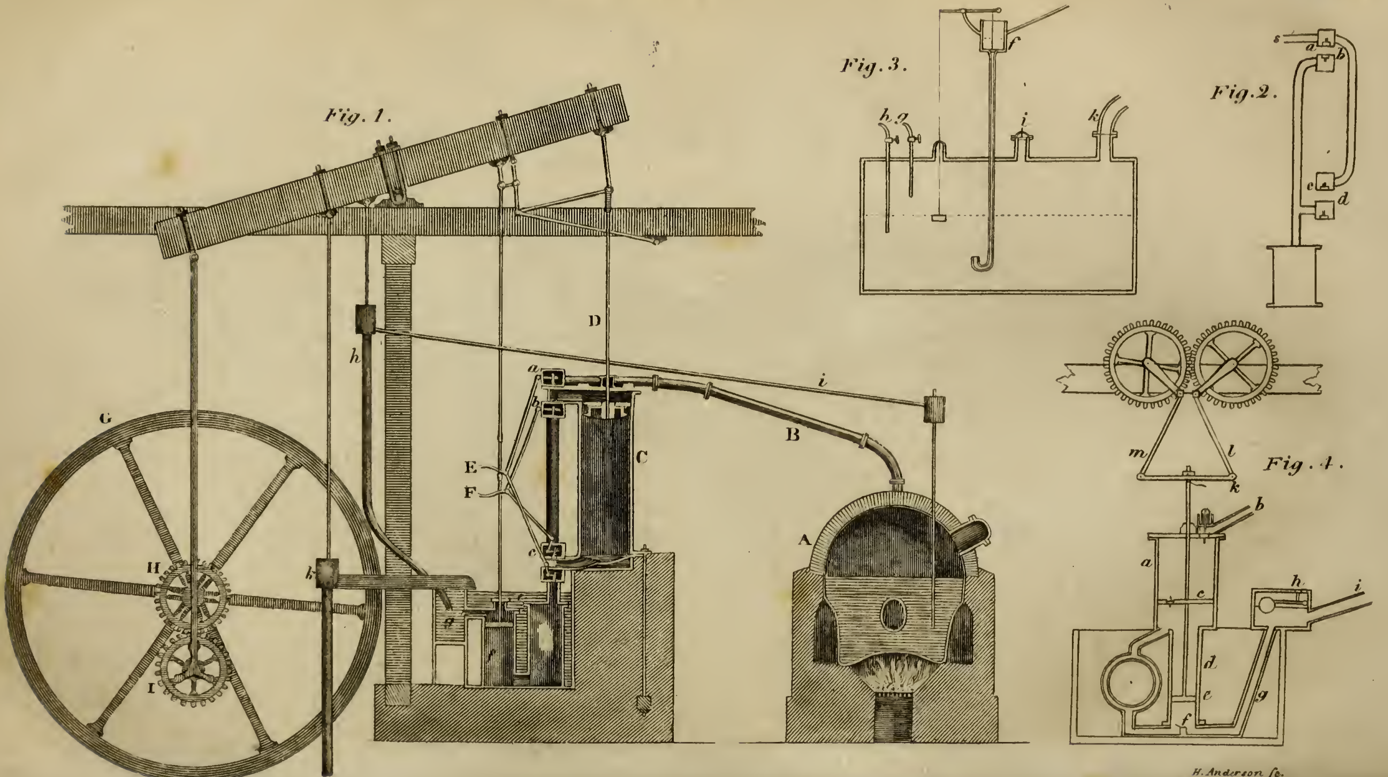
But before we explain Mr. Watt's engines, it is necessary to premise a short account of the imperfections of the old steam engines, and their causes.

The steam or vapour which arises from water confined in a close vessel, and heated a few degrees above the point, at which it boils in the open air, becomes an elastic fluid, uniform and transparent, about half the gravity of atmospheric air, very much greater in bulk, than the water of which it is composed, and capable of being again reduced to water when brought into contact with matter of a less degree of heat than itself.

The pressure of the atmosphere, or any equivalent resistance, prevents the production of steam, until the water be heated to 212 degrees of Fahrenheit's thermometer; but when that pressure is removed, or the water be placed in a vessel exhausted of air, steam is produced from it when it is colder than the human blood.

Steam Engine.

Plate. 19.



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On the contrary, if water be pressed upon by air or steam, which are more compressed than the atmosphere, a degree of heat above 212 degrees, is necessary for the production of steam; and the difference of heats at which water boils under different pressures, increases in a less proportion than the pressure themselves; so that a double pressure, requires less than a double increase of sensible heat.

The experiments which have been published, concerning the bulk of water when converted into steam, are erroneous; and the conclusions drawn from them make that bulk greater than it really is. It has been known for some time, that water would boil in an exhausted receiver at a low degree of heat.

If we consider the common steam engine, we shall find it defective; first, because the vacuum is produced by throwing cold water into the cylinder, to condense the steam: that water becomes hot, and being in a vessel partially exhausted, produces a steam, which in part resists the pressure of the atmosphere upon the piston, and lessens the power of the engine. The second defect is the destruction of steam, which unavoidably happens upon attempting to fill a cold cylinder, with that fluid; for the injection-water, at the same time that it condenses the steam, not only cools the cylinder, but remains there, until it be extruded at the eduction-pipe, by the steam which is let in to fill the cylinder for the next stroke; and that steam will be condensed into water, as fast as it enters, until all the matter which comes in contact, will be nearly as hot as itself.

Every attempt to make the vacuum more perfect, by the addition of injection water, will cool the cylinder more effectually, and cause a great destruction of steam in the next filling; and if the engine has already a proper load, the destruction of steam will proceed in a greater ratio, than the increase of power by the amendment of the vacuum.

Though it appears that the constructors of steam engines, have never investigated these causes; yet they have been so sensible of the effects, that a judicious engineer does not attempt to load his engine, with a column of water 7 lbs. for each square inch, of the area of the piston.

Mr. Watt's improvements are founded upon these, and some other collateral observations. He preserves an uniform heat in the cylinder of his engines, by suffering no cold water to touch it, and by protecting it from the air or other cold bodies, by a surrounding case filled with the steam, or with hot air or water, and by coating it over with substances, that transmit heat slowly. He makes his vacuum to approach nearly to that of the barometer, by condensing the steam in a separate vessel, called the condenser; which may be cooled at pleasure, without cooling the cylinder, either by injection of cold water, or by surrounding the condenser with it; and generally by both. He extracts the injection-water and detached air, from the cylinder or condenser, by pumps, which are wrought by the engine itself; or he blows it out by the steam.

As the inside of the cylinder was in the old engine exposed to the air, at every stroke when the piston descended, and was considerably cooled thereby, he incloses the top of the cylinder, by a metal plate, having a hole in it, through which the piston-rod works in a collar of leathers; and instead of employing the pressure of the atmosphere, to force down the piston, he introduced the steam above the piston, when the vacuum is formed underneath, and employs it to produce this effect: thus making the direct pressure of the steam, the moving power, as in the original construction of the engine.

The last great improvement made by Mr. Watt, was his giving an impulse to the piston by the steam, both in descending and ascending, instead of being impelled, as in the old engine, during the descent of the piston only.

Having thus briefly mentioned the principal improvements, made in the steam engine, by Mr. Watt, we shall proceed to describe one of his engines, on the latest construction.

A is the boiler, to which Mr. Watt has paid very great attention. It is generally of an oblong form; and the flame, after striking on its concave bottom, circulates round the sides, and sometimes returns in a pipe through the body of the water, before it is suffered to go up into the chimney. In his engines there are commonly two of these boilers, so that one of them may work, while the other is repairing. B (Plate XIX. Fig. 1.) is the steam pipe, which conveys the steam to the cylinder C, which is cased, and closed at top by a plate, having a collar of leathers, through which the piston-rod D works. *a* and *c* are the steam-valves, through which the steam enters into the cylinder: it is admitted through *a*, when it is to press the piston downwards, and through *c* when it presses upwards. *b* and *d* are the eduction-valves, through which the steam passes from the cylinder into the condenser *e*, which is a separate ves-

sel placed in a cistern of cold water, and which has a jet of cold water continually playing up in the inside of it. *f* is the air-pump, which extracts the air and water from the condenser. It is worked by the great beam or lever, and the water brought by it from the condenser, after being brought into the hot-well *g*, is pumped up again by the pump *h*, and is brought back again into the boiler by the pipe *i*. *k* is another pump, also worked by the engine itself, which supplies the cistern in which the condenser is placed, with cold water.

In the old engines, where the working-stroke was only downwards, the piston-rod was attached to the beam by chains, which bent round an arch on the end of the beam, in order to make the piston-rod move always in a perpendicular direction. This may be seen in the plate of Newcomen's engine But in Mr. Watt's engines, where the working-stroke is doubled, that is, both upwards and downwards, chains could not answer this purpose, as, when the piston was forced upwards, they would slacken, and would not communicate the motion to the beam. It was necessary, therefore, that the piston-rod should be fastened to the beam by inflexible bars; but that the stroke might be perpendicular, a particular contrivance was invented by Mr. Watt, which is exhibited in Plate XIX. and which answers the intended purpose admirably It is usually called the parallel-joint; and its nature and construction will be easily understood from the figure. In order to make the engine itself open and shut, the steam and eduction-valves, long levers are attached to them, which are moved by the piston-rod of the air-pump EF. This part of the apparatus, is called the working-geer, and is so contrived, that the valves may be worked either by hand, or by the perpendicular rod. By shutting these valves, the engine may be stopped in an instant.

In order to communicate a rotatory motion to any machinery, by the motion of the beam of the steam engine, Mr. Watt makes use of a very large fly-wheel G; on the axis of which is a small concentric toothed wheel, H. A similar toothed-wheel, I, is fastened by straps, to a rod coming from the end of the beam, so that it cannot turn round on its axis, but must rise and fall, with the motion of the great beam.

A bar of iron connects the centres of these two small-toothed wheels, so that they cannot quit each other. When, therefore, the beam raises the wheel I, it must move round the circumference of the wheel H, and turn it together with the fly: and it will be evident, upon consideration, that the fly, driven in this manner, will make two revolutions for every one of the wheel I. This mode of moving the fly, is preferable to a crank: as it goes with twice the velocity. This contrivance is called the sun and planet wheel, from the resemblance of the motion to that of those luminaries.

The valves of this steam engine are all puppet-valves, as these are found less liable to be out of order.

The mode of operation in Mr. Watt's engine, is as follows:

Suppose the piston at the top of the cylinder, in the situation represented in the plate, and the lower part of the cylinder filled with steam. By means of the handle E, open the steam-valve *a*, and the eduction-valve *d*, the levers of which are connected together; there being now a communication between the cylinder and the condenser, the steam instantly rushes into the condenser, leaving the cylinder empty. whilst at the same time the steam from the boiler, entering by the steam-valve, *a*, presses upon the piston, and forces it down. As soon as the piston has arrived at the bottom, the steam-valve *c*, and the eduction-valve *b*, are opened, whilst the valves *a* and *d* are shut; the steam therefore immediately rushes through the eduction-valve *b*, into the condenser, whilst the piston is forced up again by the steam, which is now admitted by the steam-valve *c*.

Fig. 2, which is a section of the steam-pipes, taken at right angles to that in Fig. 1, shews this more distinctly; *s* is the pipe which conveys the steam from the boiler; *a* and *c* are the steam-valves, and *b* and *d* the eduction-valves. By attending to the operation in both the sections, the reader will easily understand it. It appears at first a little confused, by there seeming to be only one steam pipe for communicating between the cylinder and the condenser; but the difficulty is cleared up, by representing both the pipes, as in Fig. 2.

Fig. 3, is a longitudinal section of the boiler, representing the mode of supplying it with water, and the safety-valve and cocks. *f* is a small cistern, which is supplied with water from the hot-well, as represented in Fig. 1; from the bottom of this cistern, a pipe goes down almost to the bottom of the boiler, where it turns up a little, to prevent the entrance of the steam which rises from the bottom. From the side of this cistern, is supported a small lever, to one end of which is fastened a wire, that carries a stone which

hangs in the water of the boiler; the other end of the lever supporting also by a wire, a valve that shuts the top of the pipe that goes down from the cistern. Now, supposing the stone just at the surface of the water, and balanced by a weight at the opposite end of the lever; it is evident, that by the laws of hydrostatics, already explained, a certain part of the weight of the stone will be supported by the water, so long as it continues immersed in it; but if a part of the water evaporate by boiling, a proportional part of the stone will be above the water, consequently the stone will bear more upon the lever, and raise the weight at the other end; but in raising that weight, it also opens the valve in the small cistern, and admits water until it stand at the same height in the boiler as before, and then the valve and the stone being again in equilibrio, the valve remains shut until a new quantity is evaporated. By this means the supply of water is very gradual, and not by fits and starts, as here described for the sake of illustration.

It is found by experience, to be a much better method than a ball-cock, and the regular supply of the boiler with water, is of the first importance. As a check upon this, and to know perfectly the height of the water in the boiler, there are two cocks, *g* and *h*, one of which reaches nearly to the surface of the water when at its proper height, and the other enters a little below the surface.

It is evident, that if the water be at the just height, and you open *g*, that steam will issue; and if *h* be opened, water will be driven out by the pressure of the steam. But if water come out from *g*, then the water must be too high in the boiler; and if steam issue from *h*, then the water is too low. By this means, it is easy to know at all times the exact height of the water in the boiler.

i is a safety-valve, to prevent the bursting of the boiler by the steam growing too strong; *k* is the pipe which conveys the steam to the engine.

Fig. 4, is Mr. Cartwright's steam-engine, the construction of which evinces much ingenuity. *a* is the cylinder, which is supplied with steam from the boiler through the pipe *b*; *c* is the piston in the act of going up; *d* is the pipe that conducts the steam into the condenser *e*, which consists of two cylinders, one within the other, leaving a small space between them, into which the steam is admitted; while the inner cylinder is filled with cold water, and also the external cylinder surrounded by the same; so that, by this means, a very large surface of steam is exposed, though no water is suffered to come into actual contact with it.

To the bottom of the piston, *c*, is attached a rod, with another piston, *e*, working in the pipe *d*. When the piston *e* arrives at the bottom of the cylinder, a valve which is in the piston, is opened by its pressing against the bottom, and opens a communication with the condenser, whilst the spring *k*, fixed to the rod of the piston, shuts the valve which admits the steam from the boiler. The steam, therefore, being thus condensed, runs into the lower pipe *f*. The piston *e* arriving at the bottom of the pipe in which it works at the same time with *c*, presses upon the condensed water, shuts the valve *f*, and forces the water up the pipe *g*, into the box *h*. The air which is disengaged from the water, rises to the top of the box, and, by its elasticity, forces the water through the pipe *i*, which carries it back again into the boiler. When the air accumulates in the box to such a degree as to depress the water, the ball-cock falls with it, and opens a valve in the top of the box, which suffers some of the air to escape.

When all the steam is condensed, the motion of the fly attached to the machine brings the piston up again, its valve now remaining shut by its weight. On arriving at the top, it presses up the steam-valve, which admits the steam from the boiler to force it down as before.

l and *m* are two cranks, upon whose axis are two equal wheels working in each other, for the purpose of converting the perpendicular motion of the piston-rod into a rotatory motion, for working the machinery attached to it.

But the most valuable part of this engine is in the construction of the piston, which Mr. Cartwright made wholly of metal, and so as, by means of springs, to fit the cylinder very exactly. This not only saves the expense and trouble of packing, which they are obliged frequently to renew in all other engines, but also saves a great deal of steam, on account of the more accurate fitting of the piston.

As it is evident, from its construction, that the whole of the steam is brought back again into the boiler, it affords the means of employing ardent spirit instead of water, and thus saving a great deal of fuel.

Dr. Smith says, that in the first fire engine, a boy was constantly employed to open and shut alternately the communication between the boiler and cylinder, accordingly as the piston either ascended or descended. One of these boys who loved to play with his companions, observed,

that by tying a string, from the handle of the valve which opened this communication, to another part of the machine, the valve would open and shut without his assistance, and leave him at liberty to divert himself with his playfellows. One of the greatest improvements that have been made upon this machine since it was first invented, was in this manner the discovery of a boy who wanted to save his own labour.

About ten months ago, Mr. Arthur Woolf announced to the public a discovery respecting the expansibility of steam, which promises to be of very essential utility. Mr. Watt had formerly ascertained, that steam which acts with the expansive force of 4 pounds per square inch, against a safety-valve exposed to the weight of the atmosphere, after expanding itself to four times the volume it thus occupies, is still equal to the pressure of the atmosphere. But Mr. Woolf has gone much farther, and has proved, that quantities of steam, having the force of 5, 6, 7, 8, 9, 10, &c. pounds on every square inch, may be allowed to expand 5, 6, 7, 8, 9, 10, &c. times its volume, and will still be equal to the atmosphere's weight, provided that the cylinder in which the expansion takes place, has the same temperature as the steam before it began to expand. It is evident, however, that an increase of temperature is necessary both to produce and to maintain this augmentation of the steam's expansive force above the pressure of the atmosphere. At the temperature of 212° of Fahrenheit, the force of steam is equal only to the pressure of the atmosphere, and, in order to give it an additional elastic force of 5 pounds per square inch, the temperature must be increased to about $227\frac{1}{2}$°, as is evident from the following table.

Table of the pressures, temperatures, and expansibility, of steam, equal to the force of the atmosphere.

Elastic force of steam predominating over the pressure of the atmosphere, and acting upon a safety-valve.	Degrees of temperature requisite for bringing the steam to the different expansive forces in the preceding column.	No. of times its vol. that steam of the preceding force and temperature will expand, and still continue equal to the pressure of the atmosphere.
Pounds per square inch.	Degrees of heat.	Expansibility.
5	$227\frac{1}{2}$	5
6	$230\frac{1}{4}$	6
7	$232\frac{3}{4}$	7
8	$235\frac{1}{4}$	8
9	$237\frac{1}{2}$	9
10	$239\frac{1}{2}$	10
15	$250\frac{1}{2}$	15
20	$259\frac{1}{2}$	20
25	267	25
30	273	30
35	278	35
40	282	40

In this manner, by small additions of temperature, an expansive power may be given to steam, which will enable it to expand 50, 100, 200, 300, &c. times its volume, and still have the same force as the atmosphere.

Upon this principle Mr. Woolf has taken out a patent for various improvements on the steam engine, a short account of which we shall subjoin in the words of the specification.

If the engine be constructed originally with the intention of adopting the preceding improvement, it ought to have two steam vessels of different dimensions, according to the expansive force to be communicated to the beam, for the smaller steam cylinder must be a measure for the larger. For example, if steam of 40 pounds the square inch be fixed on, then the smaller steam vessel should be at least 1-46th part the contents of the larger one. Each steam vessel should be furnished with a piston, and the smaller cylinder

should have a communication both at its top and bottom, with the boiler which supplies the steam; which communications, by means of cocks or valves, are to be alternately opened and shut during the working of the engine. The top of the smaller cylinder should have a communication with the bottom of the larger cylinder, and the bottom of the smaller one with the top of the larger, with proper means to open and shut these alternately by cocks, valves, or any other contrivance. And both the top and bottom of the larger cylinder should, while the engine is at work, communicate alternately with a condensing vessel, into which a jet of water is admitted to hasten the condensation. Things being thus arranged when the engine is at work, steam of high temperature is admitted from the boiler to act by its elastic force on one side of the smaller piston, while the steam which had last moved it has a communication with the larger cylinder, where it follows the larger piston now moving towards the end of its cylinder which is open to the condensing vessel. Let both pistons end their stroke at one time, and let us now suppose them both at the top of their respective cylinders ready to descend; then the steam of 40 pounds the square inch, entering above the smaller piston, will carry it downwards, while the steam below it, instead of being allowed to escape into the atmosphere, or applied to any other purpose, will pass into the larger cylinder above its piston, which will take its downward stroke at the same time that the piston of the smaller cylinder is doing the same thing; and, while this goes on, the steam which last filled the larger cylinder, in the upward stroke of the engine, will be passing into the condenser, to be condensed in the downward stroke. When the pistons in the smaller and larger cylinder have thus been made to descend to the bottom of their cylinders, then the steam from the boiler is to be shut off from the top, and admitted to the bottom of the smaller cylinder, and the communication between the bottom of the smaller, and the top of the larger cylinder is also to be cut off, and the communication to be opened between top of the smaller and the bottom of the larger cylinder; the steam which, in the downward stroke of the engine, filled the larger cylinder being now open to the condenser, and the communication between the bottom of the larger cylinder and the condenser cut off; and so on alternately, admitting the steam to the different sides of the smaller piston, while the steam last admitted into the smaller cylinder passes alternately to the different sides of the larger piston in the larger cylinder, the top and bottom of which are made to communicate alternately with the condenser.

In an engine where these improvements are adopted, that waste of steam which arises in other engines from steam passing the piston, is totally prevented, for the steam which passes the piston in the smaller cylinder is received into the larger.'

Mr. Woolf has also shown how the preceding arrangement may be altered, and has pointed out various other modifications of his invention, and the method of applying his improvements to steam engines which are already constructed.

On the Power of Steam Engines, and the Method of computing it.

From the account which has been given of the steam engine, and the mode of its operation, it must be evident that its power depends upon the breadth and height of the cylinder, or in other words, on the area of the piston and the length of its stroke. If we suppose that no force is lost in overcoming the inertia of the great beam, and that the lever by which the power acts is equal to the lever of resistance; then, if steam of a certain elastic force be admitted above the piston, so as to press it downwards with a force of a little more than 100 pounds, it will be able to raise a weight of 100 pounds hanging at the end of the great beam. When the piston has descended to the bottom of the cylinder, through the space of four feet, the weight will have risen through the same space, and 100 pounds raised through the height of four feet, during one descent of the piston, will express the mechanical power of the engine. But if the area of the piston, and the length of the cylinder be doubled, while the expansive force of the steam, and the time of the piston's descent remain the same, the mechanical energy of the engine will be quadruple, and will be represented by 200 pounds raised through the space of eight feet during the time of the piston's descent. The power of steam engines therefore is, *ceteris paribus*, in the compound ratio of the area of the piston, and the length of the stroke. These observations being premised, it will be easy to compute the power of steam engines of any size.

Thus, let it be required to determine the power of a steam engine whose cylinder is 24 inches diameter, and which makes 22 double strokes in a minute, each stroke being 5 feet long, and the force of the steam being equal to a pres-

sure of 12 pounds avoirdupois upon every square inch. [The working power is generally reckoned at 10 lbs. on every circular inch, and Smeaton makes it only 7 lbs. The effective pressure which we have adopted is between these extremes, being equivalent to 9.42 lbs. on every circular inch.] The diameter of the piston being multiplied by its circumference, and divided by 4, will give its area in square inches; thus, $\frac{24 \times 3.1416 \times 24}{4} = 452.4$, the number of square inches exposed to the pressure of the steam. Now if we multiply this area by 12 pounds, the pressure upon every square inch, we will have $452.4 \times 12 = 5428.8$ pounds the whole pressure upon the piston, or the weight which the engine is capable of raising. But since the engine performs 22 *double* strokes, 5 feet long in a minute, the piston must move through $22 \times 5 \times 2 = 220$ feet in the same time; and therefore the power of the engine will be represented by 5428.8 pounds avoirdupois, raised through 220 feet in a minute, or 10.4 hogsheads of water, ale measure, raised through the same height in the same time. Now this is equivalent to $5428.8 \times 220 = 1194336$ pounds, or $10.4 \times 220 = 2288$ hoghsheads raised through the height of 1 foot in a minute. This is the most unequivocal expression of the mechanical power of any machine whatever, that can possibly be obtained. But as steam engines were substituted in the room of horses, it has been customary to calculate their mechanical energy in *horse-powers*, or to find the number of horses which could perform the same work. This indeed is a very vague expression of power, on account of the different degrees of strength which different horses possess. But still, when we are told that a steam engine is equal to 16 horses, we have a more distinct conception of its power, than when we are informed that it is capable of raising a number of pounds through a certain space in a certain time.

Messrs. Watt and Boulton suppose a horse capable of raising 32,000 pounds avoirdupoise, one foot high in a minute, while Dr. Desaguliers makes it 27,500 pounds, and Mr. Smeaton only 22,916. If we divide, therefore, the number of pounds which any steam engine can raise one foot high in a minute, by these three numbers, each quotient will represent the number of horses to which the engine is equivalent. Thus, in the present example $\frac{1194336}{32000} = 37$ 1-3 horses according to Watt and Boulton; $\frac{1194336}{27500} = 43$ 1-3 horses, according to Desaguliers; and $\frac{1194336}{22916} = 52$ 1-7 horses, accordind to Smeaton. In this calculation it is supposed that the engine works only eight hours a-day; so that if wrought during the whole 24 hours, it would be equivalent to thrice the number of horses found by the preceding rule. We cannot help observing, and it is with sincere pleasure that we pay that tribute of respect to the honour and integrity of Messrs. Watt and Boulton, which has every where been paid to their talents and genius,—that in estimating the power of a horse, they have assigned a value the most unfavourable to their own interests. While Mr. Smeaton and Dr. Desaguliers would have made the engine in the preceding example equivalent to 52 or 53 horses; the patentees themselves state that it will perform the work only of 37. How unlike is this conduct to some of our modern inventors, who ascribe powers to their machines which cannot possibly belong to them, and employ the meanest arts for ensnaring the public.

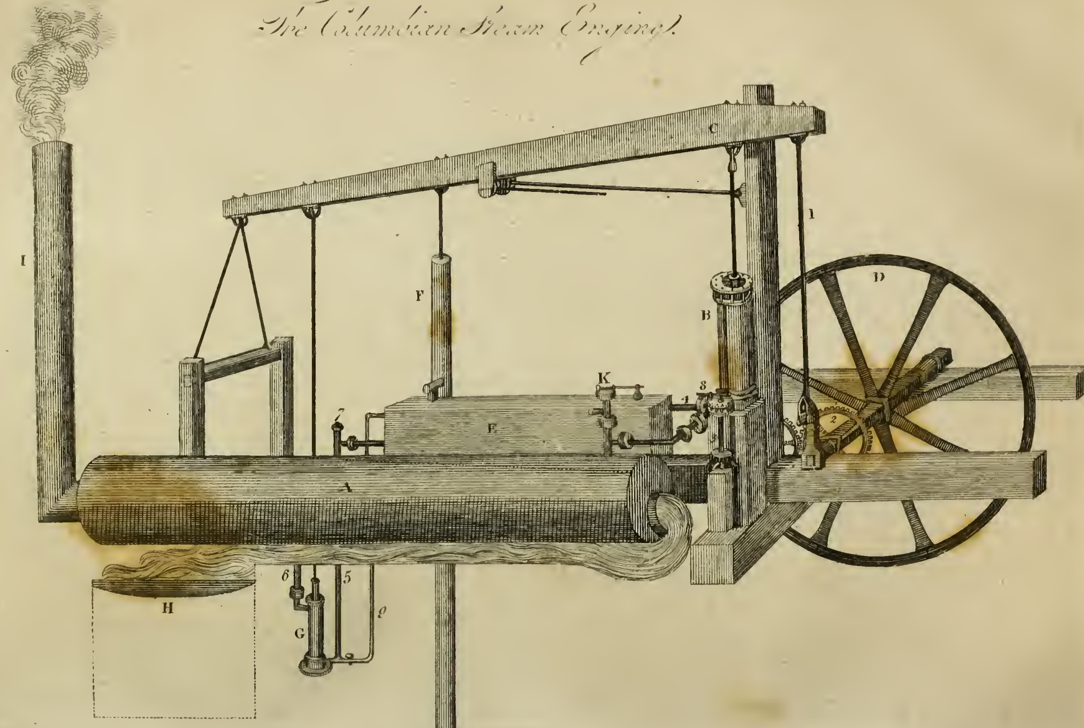
We shall now state the performance of some of these engines, as determined by experiment. An engine whose cylinder is 31 inches in diameter, and which makes 17 double strokes per minute, is equivalent to 40 horses, working day and night, and burns 11,000 pounds of Staffordshire coal per day. When the cylinder is 19 inches, and the engine makes 25 strokes of 4 feet each per minute, its power is equal to that of 12 horses working constantly, and burns 3,700 pounds of coals per day. And a cylinder of 24 inches, which makes 22 strokes of 5 feet each, performs the work of 20 horses, working constantly, and burns 5,500 pounds of coals. Mr. Boulton has estimated their performance in a different manner. He states that one bashel of Newcastle coals, containing 84 pounds, will raise 30 million pounds one foot high; that it will grind and dress 11 bushels of wheat; that it will slit and draw into nails 5 cwt. of iron; that it will drive 1,000 cotton spindles, with all the preparation-machinery, with the proper velocity; and that these effects are equivalent to the work of ten horses.

Mr. Boulton has lately constructed an apparatus for coining, which moves by an improved steam engine. The machinery is so ingeniously constructed, that four boys of ten or twelve years of age are capable of striking 30,000 guineas in an hour and the machine itself keeps an accurate account of the number which is struck.

It is due to the merits of our country-

Plate XX.

The Columbian Steam Engine.



J.H. Seymour sc.

men to say, that considerable improvements on the steam engine have been made in this country. Among the number, we mention with pleasure, the improvements of Oliver Evans, esq., some of which we present the reader in this place. The following explanation of the Columbian Engine we were politely furnished with by the patentee. For further information on steam engines, we refer the reader to Evans's Treatise on Steam Engines, a work which abounds with much practical and theoretical knowledge.

The Columbian Steam Engine.
Plate XX.

A, the boiler.
B, the working cylinder.
C, the lever beam.
D, the fly-wheel.
E, the condenser.
F, the water-pump.
G, the supply pump.
H, the furnace.
I, the chimney flue.
K, the safety-valve, which may be loaded with 100 or 150 lbs. to the inch area; it will never need more, and it must never be fastened down.

Operation.

The boiler being filled with pure water as high as the dotted line, and the fire applied, the smoke enters the centre flue, which passes through the centre of the water to ascend the flue I, and thus acts on a large surface.

When the steam lifts the safety-valve, it is then let into the cylinder by opening the throttle-valves, to drive the piston up and down, which, by rod 1, gives motion to the fly-wheel, and wheel 2 gives motion to a shaft, passing through the posts, to turn the spindle of the rotatory valves, 3, 8, which lets the steam both off and on the cylinder at the proper time.

The steam escaping by pipe 4, curved and immersed in the water in box E, which is supplied by pump F, it is condensed, and the water formed, descends by pipe 5 into supply-pump G, and is forced into the boiler again by pipe 6.

The snifting-valve 7, is necessary.—This valve lifts at every puff of steam, and a small quantity of air escapes; and it shuts, and a vacuum is instantly formed, as the crank passes the dead points.

The small waste of water may be supplied by condensing part of the steam rising from the condensing water, to run down the pipe 9, through a hole in the key of a stop-cock, one-thirty-second part of an inch diameter,—a small hole indeed to supply a boiler of twenty horses power.

No sediment can accumulate in the boiler, it being supplied by distilled water. Therefore it will last much longer, and require less fuel than others. Muddy, limestone, or salt water, or the juice of the sugar cane, &c. &c., may be used to condense; and as the engine works equally well while we boil away the condensing water, we may boil for salt, sugar, &c., in working the engine,—thus using the fuel for double purposes.

If the steam be confined by the load on the safety-valve, to raise its power to 100 pounds to the inch area of the piston, and the cylinder be nine inches in diameter, and the stroke of the piston three feet, the power will equal twenty horses hitched; and will grind 20 bushels of grain per hour, or saw 5000 feet of boards in twelve hours. If the steam be confined by 150 pounds, the power of the engine will be equal to thirty horses, when the steam is shut off at one-third of the stroke, and striking thirty-six strokes per minute.—Double strokes double the power

The more the steam is confined, and the shorter it be shut off by the regulator, 8, the greater will be the power obtained by the fuel. For every addition of 30 degrees heat to the water doubles the power. So that doubling the heat of the water, increases the power about 100 times. On these principles fuel may be lessened to one third part consumed by other engines. This engine is not more than one-fourth the weight of others; is more simple, durable, and cheap, and more suitable for every purpose; especially for propelling boats and land carriages. It requires no more water than the fuel will evaporate in steam, and this steam may be employed to warm the apartments of factories; or the condenser E could be used as a still to distil spirits, or a vat for paper making, boiler in a brewery, dye factory, &c. &c.

In the Philadelphia steam engines (says Mr. Fessenden,) certain innovations have been introduced, which we hope may be found to be improvements. What are styled the improvements, consist, principally, in making use of a wooden chest to contain the water, through which the flues of the furnace wind several times before their discharge into the chimney.

These wooden boilers are supposed to be serviceable in consequence of their being slow conductors of heat, and the long cylindrical heaters exposing a very great surface of iron to the action of the water. The steam engine in Centre Square is a double steam engine, with a

cylinder of thirty-two inches. Its power is calculated for not merely the present, but the future wants of this city. It makes twelve strokes of six feet per minute, for sixteen hours in twenty-four, in which time it consumes from twenty-five to thirty-three bushels of Virginia coals of the best sort.

Some inconveniences are said to attend these wooden boilers, such as steam leaking the joints and at the bolts. A conical wooden boiler has been adopted as it appears at the suggestion of Mr. Oliver Evans, with hoops, which promises every wished for success. It was found that a combination of oak and pine in the same boiler was liable to premature decay in consequence of the pine being acted upon by the acid of the oak.

At the lower engine, next the Schuylkill, which is a double steam engine of forty inches cylinder, and six feet stroke, a cast iron boiler has been put up, with straight sides and semicircular ends; seventeen feet long and eight feet wide at the bottom; nineteen feet long and ten feet wide at the height of five feet seven inches. At this height it is covered by a vault, which in its transverse section is semicircular, and in its longitudinal section exhibits half its plan. The bottom is concave every way, rising one foot in the centre. The fire place is six feet long and four feet wide on an average, and is under one extreme end of the bottom. The fire-bed is arched, parallel with the bottom, and a space of one foot left for the passage of the flame. The flame by means of flues and an arch of bricks, is made to pass several times through and round the boiler. The boiler is composed of seventy plates of iron, cast with flanches and bolted together, so that the flanch and bolts are within the water, and is tied together by numerous braces. This boiler consumed fifty bushels of coals and one half cord of wood while rolling iron twelve hours at twenty strokes a minute.

STEEL. See Iron.

STEEL YARD. See Mechanics.

STENCILLING. In relation to this art, we shall add a few remarks on the mechanical means for copying drawings.

There are various methods by which those who are ignorant of the art of drawing, may copy very accurately the outlines of pictures, prints, and drawings; and these methods are often useful to those who can draw, and to engravers, when either great expedition or great accuracy is required; though none of them should ever be used by one who is learning to draw.

Tracing against the Light.

Hold the drawing you wish to copy against one of the panes of the window, or have a pane of glass put in a frame, and fitted up like a music-stand, with a candle behind it. Lay your paper over the drawing, and you will see all the lines of the original distinctly through it, by which means you can easily trace them with a pen or black-lead pencil.

To make Tracing-Paper.

Mix together equal parts of oil of turpentine and drying-oil, and with a rag rub it evenly over some fan, or tissue-paper, or any other very thin paper. Hang it by to dry for a day or two, and it will be fit for use. Lay this over the print or drawing you want to copy, and you will see every line distinctly through, so that you can go over them with the black-lead pencil. If you wish to do it in ink, you must mix a little ox's gall with the ink, to make the paper take it, which it would not otherwise do, on account of the oil.

To make Camp-Paper.

Take some hard soap, mix it with lamp-black; make it into the consistence of a jelly with water; with this, brush over one side of your paper, and let it dry. When you use it, put it between two sheets of clean paper, with its black side downwards, and with a pin, or stick with a sharp point, draw or write what you please upon the clean paper; and where the tracer has touched, there will be an impression upon the lowermost sheet of paper, as if it had been written or drawn with a pen. It may be made of any colour, by mixing with the soap black-lead, vermillion, &c.

Stencilling.

Lay the print or drawing you wish to have copied, over a sheet of paper, and with a pin or needle, prick all the outline over with holes, through both the papers. Then take the clean paper with the holes made in it, and lay it upon the paper you wish to have the design transferred to, and dust it over with the powder of charcoal in a small muslin bag; the dust will penetrate through the holes, and leave a correct copy of the original upon the paper.

This pricked paper will do again for any number of copies. This is very useful for ladies, who work flowers upon muslin.

STILL. See Distilling Apparatus.

STILTON CHEESE. See CHEESE.
STONE COAL See COAL.
STONE WARE. See POTTERY.

STOVE, an apparatus in which fires are made for various purposes. As much has been written on the best construction of stoves, for various purposes, we shall endeavour to present our readers with a general view.

On the subject of stoves, it may be said in general terms, that from the earliest ages, mankind have directed their attention, to the construction of conveniences, for the purpose of warming rooms, cooking, &c. though no doubt their attempts were rude, and their uses confined.

In the construction of any stove, a great point is gained, and ought always to be duly estimated, if the object of economizing or saving fuel is accomplished; and their construction should be such, as to produce the effect, with the least possible supply of wood or coal. The amazing quantity of heat, which is usually lost, is sufficient to direct our attention to the object before-mentioned.

The following is a description of a stove on the principles of the Swedish fire-place, with head openings, by Citizen Guyton.

The true principles of constructing fire-places, so as to obtain the greatest heat, with the least consumption of fuel, have been known for some time in France; but they have been much less generally adopted, than the necessity for economizing fuel demands. We see many fire-places, so deep as to consume double the quantity of fuel necessary, and yet heat the apartment but faintly, where half the expense might be spared by altering the fire-place, according to Count Rumford's plan.

If a chimney smoke, instead of reducing the tunnel to proper dimensions, so that descending currents cannot take place in it, scarcely any remedy is thought of but air-holes, which require the sacrifice of a certain quantity of fuel, to counterbalance the effect of the cold air continually entering.

The use of the Swedish stoves is probably yet rare, from their not having been constructed on just principles, or in the best proportions, at their first introduction. As I have had one made, which appears to many of my friends, to produce an astonishing effect, in compliance with their request, I shall give an exact description of it, premising however, a few principles with regard to fires.

1. The heat produced is proportionate only to the air consumed by the fuel.

2. The quantity of heat produced by a given quantity of fuel, is greatest when the combustion is most complete.

3. The combustion is most complete when the fuliginous part of the fuel is retained longest in pipes, in which it may undergo a second combustion.

4. Of the heat produced none is of use, but what is diffused through the space to be heated, and retained in this space.

5. The temperature in this space will be higher, in proportion as the current of air, which is to renew and keep up the combustion, is less disposed to absorb the heat of this space in passing through it.

Hence we deduce the following obvious consequences:

1. The fire-place must be kept separate from all bodies that conduct heat rapidly.

2. As heat can be produced only by combustion, and combustion can be maintained only by a current of air, this current should be attracted into pipes, where it preserves the requisite velocity, without going away from the place to be heated; so that the heat it deposits in it, gradually accumulates, in the whole of the isolated stove, to be afterwards given out slowly, according to the laws of its equilibrium.

3. When the wood is consumed to such a point, as to afford no more smoke, it is of advantage to stop the outlets of these pipes, to keep in the heat, which would be carried into the chimney, by the continued current of fresh air, which would necessarily be of a lower temperature.

4. We shall obtain a higher temperature, and preserve it longer, under similar circumstances, if we construct within the stove, or under the hearth, and round the fire-place, pipes in which the air derived from without, is warmed before it enters into the apartment, to support the fire, or to replace what has been consumed.

These pipes are what have been called heat openings, (*bouches de chaleur,*) because instead of considering their principal object, it is commonly supposed, that they are made to give a more rapid passage to the heat produced. This is not totally without foundation, since the temperature of the air issuing from them is increased by the heat it absorbs from the stove; and on this account, some might be disposed to neglect them, as contrary to the most essential object, that of retaining the heat in it; but it is to be observed, that we can shut these outlets when we please; and that we may even cut off all communication with the external air, by means of a simple slider; so that eve-

ry advantage may be derived from them, without any inconvenience. It must be added, that they are necessary in very close apartments, unless we would expose ourselves to currents of cold air.

The Swedish stoves are constructed according to the truest principles, and the pipes in which the smoke circulates, are disposed in the best manner, for effecting its complete combustion. Their utility has been found so great, that they have become general in Sweden, where the winters are very severe, and where they have diminished the consumption of wood one-third, so that there is no country where the inclemency of the weather, is guarded against, at less expense. They have likewise been employed advantageously, with the necessary variations of form, in dye-houses, breweries, &c.

Their construction is by no means expensive; they save iron-work, and require only bricks or tiles. These are recommended to be placed edgewise, and chosen as thin as possible for the inner walls. The circulating pipes are to be placed so, that rain falling down the chimney, can never get into them. The method of using them is so easy, that in the largest public buildings, one person is sufficient to light all the fires. All the wood that can be contained in the fire-place, which is very small, is to be put in at once; it is to be sawed into pieces of equal lengths; and as soon as it is burned, the slider that stops the communication of the circulating pipes with the chimney, is to be thrust in. By these means all the heat, which the fuel is capable of producing, remains in the pipes, and issues out slowly, and only to diffuse itself in the apartment; while a single piece of wood, that had not burned at the same time with the rest, would oblige the slide to be left open, and the current of air necessary for its combustion, would carry off into the chimney, the greater part of the heat produced. A review of the stove may be seen in Coxe's Emporium, vol. 1. No. 2, p. 105.

Stove for warming large apartments.

The following description of an economical mode of warming large apartments, by means of heated air, is taken from the Edinburgh Medical and Surgical Journal, vol. 4. It is in operation at the public hospital of the town of Nottingham, in England, in the large manufactories of Nottingham and Derbyshire, and in the opinion of Dr. Mease, it is so obviously preferable to the mode of warming rooms by means of close iron stoves, that it ought to be adopted wherever pure warm air, regularity of temperature, or economy, are desirable.

These stoves were first constructed in the year 1792, in consequence of the inconvenience experienced by the then existing modes of warming the large rooms in which manufactures are carried on. The open fires consumed a large quantity of coal, without materially heating the room; the people were therefore obliged to waste much time in warming themselves, and their health could not but be injured more or less by the alternate heats and chills which they were thus obliged to experience.

The close iron stoves, so generally used, had not this inconvenience, but were, perhaps, worse upon the whole, being dusty and dangerous, and, by being heated red-hot, which they were constantly subject to be, contributed to render the air unwholesome and offensive, by the calcination of the iron, as well as by the burning of the various substances which are constantly floating in the air of a room.

To introduce a large quantity of the purest air which could be procured externally, with simplicity, and to transmit the greater part of the heat generated, whatever that may be, through the stove, and to unite it with this air, were the leading objects of the improvement.

In the common stoves, the combination of the heat that is generated with the external air is effected very imperfectly; for the air being a very bad conductor of heat, and being also transparent, is incapable of having heat communicated to it by radiation; whence it follows, that the particles of air only, which are in absolute contact with the stove, are heated by it—then ascending, in consequence of the decrease of their specific gravity, are replaced by others; but this is performed so slowly, that the stove is covered as it were by a blanket, and very easily becomes red-hot. It was therefore conceived, that if the ascending heated air was enclosed in a tunnel of considerable perpendicular height, and that if all the air which would in consequence of the ascending force of the column, tend to rush in at the bottom, was made to impinge upon all sides of the stove, it would cool the stove, by causing a much larger quantity to come in contact with it, be itself heated of course, and thus produce a very considerable and rapid current of air.

The experiment being first tried as above, in a building about 200,000 cubic feet of space, and containing a great number of windows, was found to answer completely; but the stove being made of

cast iron, wrought iron plate was substituted in subsequent experiments, as being, for many reasons, much more eligible. In some recent experiments, the sides of the stove, as well as the walls surrounding it, have been built perpendicular, at the distance of about seven inches ; and wrought iron tubes have been inserted into each hole of the side walls, as well as in the arch over the stove, like the nozles of so many bellows, which, by causing every particle of air that is admitted, to come twice in contact with the stove, is believed to be a material improvement.

A view of this stove may be seen in the Archives of useful Knowledge, No. 2, and also the new and portable stove used in Edinburgh.

Various modes, says Mr. Pettibone, have been adopted for warming rooms, &c.

Furnaces have been made under the floor of a building, attached to serpentine flues, and very similar to a common kiln for drying corn, malt, &c —The heat of which is unpleasant for respiration; also very difficult to regulate, or to keep in order.

Next, a stove or cockle has been enclosed in a sort of brick well, with a thick cast iron pipe, leading up the centre to the top of the well or building, and there ceiled, that no smoke could enter the well in contact with this stove or cockle.---Holes are made to let the heat into the various rooms, one above the other, but without success equal to the expectation.

This plan was tried in the Pennsylvania hospital. Since which it has been tried, in the year 1809, in the hospital at New-York. At this place, six stoves (in the form of a cone or sugar loaf) were fitted in wells, and to the top or small end of these stoves, a sheet or cast iron pipe, as before mentioned.---It is to be particularly observed, that these stoves and funnels, or pipes, were heated to a red heat, often from the fire to the top of the house; at which place the flame often appeared; and some of the stoves were so melted as to spoil them—and the lowermost rooms were very cold, while the uppermost were amply heated.---This hospital, as also that of Pennsylvania, is under the particular direction of gentlemen of the first respectability, and are high in the public estimation.

If they had admitted a full supply of cold external air into the well, in contact with the stove and funnel, it would have transported the heat into the various rooms :---or if placed in an air vessel within the stove and funnel, so as to cool the stove and pipe as much as possible; and have made the holes for the admission of warm air much smaller in the upper rooms; and to have prevented the sudden discharge of the flame and smoke;---they would have accomplished their design to their full satisfaction

Next to be noticed, is a stove introduced (by Mr. Pollock, of Boston,) into the hospital of New-York, and elsewhere, having a small air pipe, not exceeding two inches in diameter, through the centre of the stove upwards---the stove is in shape of a pillar, with a square base.

This air pipe, he says, is glazed internally, to preserve the goodness of the air. This, however, has never yet been done—it may have been credited by some.

For this stove, Mr Pollock obtained patents, in 1807 and 1808.—Unfortunately for Mr. Pollock, Mr. Oliver Evans, of this city, did, in 1800, obtain a patent for making stoves or fire-places, with luminous sides or doors of talc, isinglass, or other fit materials.

Further, Mr. John H. Gould, in 1808, obtained a patent for something which he considered an improvement on grates or common fire-places. It is believed that he, as well as others, were somewhat disappointed in their expectations.

Also, in 1808, Mr. Pettibone obtained a patent for his air-stove, which was highly approved of.

Mr. Pettibone's method of transporting heat from steam, by a current of fresh air, will save one half the expense now required in the European method; besides the advantage of sufficient warmth, agreeable respiration, and ventilation.

Mr. Pettibone's improvements for warming rooms, or apartments, by means of rarefied air, (applicable for ovens, drying rooms, hot, or green houses, &c. &c.) heated with or without the application of steam, called a rarefying air-stove, consists in the construction of a stove, furnace, or fire-place, with a large rarefying air-vessel, or chamber, connected with the same, or things as hereafter described.---These air-vessels, or chambers, are so constructed as to contain any kind of stove, or steam pipe, or an air vessel is placed in any stove, so that the air is heated in contact with the outside of the stove, or steam pipe, or within the stove in the air vessel---or within a steam pipe or vessel. For sundry information on this subject, see Pettibone's Economy of Fuel, &c.

On the subject of the Franklin, or Ame-

rican stove, as it is called, the following extract from the works of Dr. Franklin, may be interesting to the reader.

Speaking of the invention in his Letters on Philosophical Subjects, (page 300,) he says, In which there are hollow cavities made by iron plates in the backs, jambs, and hearths, through which plates the heat, passing, warms the *air* in those cavities, which is continually coming into the room *fresh* and *warm*. The invention was very ingenious, and had many conveniences: the room was warmed in all parts by the air flowing into it through the heated cavities; cold air was prevented rushing through the crevices, the funnel being sufficiently supplied by those cavities; much less fuel would serve, &c. But the first expense, which was very great, the intricacy of the design, and the difficulty of the execution, especially in old chimneys, discouraged the propagation of the invention.

Its advantages above the common fire-places are,

1. That your whole room is equally warmed, so that people need not crowd so close round the fire, but may sit near the window, and have the benefit of the light for reading, writing, needle-work, &c. They may sit with comfort in any part of the room, which is a very considerable advantage in a large family.

2. If you sit near the fire, you have not that cold draught of uncomfortable air nipping your back and heels, as when before common fires, by which many catch cold, being scorched before, and, as it were, frozen behind.

3. If you sit against a crevice, there is not that sharp draught of cold air playing on you, as in rooms where there are fires in the common way, by which many catch cold; whence proceed coughs, catarrhs, tooth-aches, fevers, pleurisies, and many other diseases.

4. In case of sickness, they make most excellent nursing-rooms, as they constantly supply a sufficiency of fresh air, so warmed at the same time as to be no ways inconvenient or dangerous. The equal temperature, too, and warmth of the air of the room, are thought to be particularly advantageous in some distempers; for it was observed, in the winters of 1730 and 1736, when the small-pox spread in Pennsylvania, that very few children of the Germans died of that distemper, in proportion to those of the English; which was ascribed by some to the warmth and equal temperature of the air in their stove-rooms, which made the disease as favourable as it commonly is in the West-Indies. But this conjecture we submit to the judgment of physicians.

5. In common chimneys, the strongest heat from the fire, which is upwards, goes directly up the chimney, and is lost; and there is such a strong draught into the chimney, that not only the upright heat, but also the backs, sides, and downward heats, are carried up the chimney, by that draught of air, and the warmth given before the fire, by the rays that strike out towards the room, is continually driven back, crowded into the chimney, and carried up by the same draught of air; but here the upright heat strikes and heats the top plate, which warms the air above it, and that comes into the room. The heat, likewise, which the fire communicates to the sides, back, bottom, and air box, is all brought into the room; for you will find a constant current of warm air coming out of the chimney-corner into the room. Hold a candle just under the mantle-piece, or breast of your chimney, and you will see the flame bent outwards. By laying a piece of smoking paper on the hearth, on either side, you may see how the current of air moves, and where it tends, for it will turn and carry the smoke with it.

6. Thus, as very little of the heat is lost when this fire-place is used, much less wood or fuel will serve you, which is a considerable advantage where wood is dear.

People, who have used these fire-places, differ much in their accounts of the wood saved by them; some say five-sixths, others three-fourths, and others much less. This is owing to the great difference there was in their former fires; some (according to the different circumstances of their rooms and chimneys) having been used to make very large, others middling, and others of a more sparing temper very small ones; while in these fire-places (their size and draught being nearly the same) the consumption is more equal. I suppose, taking a number of families together, that two-thirds, or half the wood, at least, is saved. My common room, I know, is made twice as warm as it used to be with a quarter the wood I formerly consumed there.

7. When you burn candles near this fire-place, you will find that the flame burns quite upright, and does not blare and run the tallow down, by drawing towards the chimney, as in common fire-places.

8. This fire-place cures most smoky chimnies, and thereby preserves both the eyes and furniture.

9. It prevents the fouling of chimneys; much of the lint and dust, that contribute to foul a chimney, being by the low arch obliged to pass through the flame, where it is consumed: then, less fuel being burnt, there is less smoke made. Again, by hanging on the blower, a flame is soon produced, and, in consequence, the same fuel does not yield so much smoke, as if burnt in a common chimney; for, as soon as flame begins, smoke in proportion ceases.

10. And if a chimney should be foul, it is much less likely to take fire; if it should take fire, it is easily stifled and extinguished.

11. A fire may be very speedily made in this fire place by the help of the above-mentioned blower. With all these conveniences, you do not lose the pleasing sight nor use of the fire.

The objections made against the use of this stove, have been abolished.

On the nature of warmth the Dr. observes, the maxim *that warm rooms make people tender, and apt to catch cold*, is a mistake as great as it is general. We have seen, in the preceding pages, how the common rooms are apt to give cold; but he affirms from his own experience, and that of his family and friends, who have used warm rooms for these four winters past, that by the use of such rooms people are rendered less liable to take cold, and, indeed, actually hardened. If sitting warm in a room made one subject to take cold on going out, lying warm in bed should, by a parity of reasoning, produce the same effect when we rise; yet we find we can leap out of the warmest bed naked, in the coldest morning, without any such danger, and in the same manner out of warm clothes into a cold bed. The reason is, that in these cases the pores all close at once, the cold is shut out, and the heat within augmented, as we soon after feel by the glowing of the flesh and skin. Thus, no one was ever known to catch cold by the use of a cold bath; and are not cold baths allowed to harden the bodies of those that use them? Are they not therefore frequently prescribed to the tenderest constitutions? Now, every time you go out of a warm room into the freezing cold air, you, as it were, plunge into a cold bath, and the effect is in proportion the same; for, though perhaps you may feel somewhat chilly at first, you find in a little time your bodies hardened and strengthened, your blood is driven round with a brisker circulation, and a comfortable, steady, uniform, inward warmth succeeds that equal outward warmth you first received in the room. Farther to confirm this assertion, we instance the Swedes, the Danes, and the Russians; these nations are said to live in rooms, compared to ours, as hot as ovens; yet, where are the hardy soldiers, though bred in their boasted cool houses, that can like these people, bear the fatigues of a winter campaign in so severe a climate, march whole days up to the neck in snow, and at night entrench in ice as they do?

The mention of those northern nations (says the doctor) puts me in mind of a considerable public advantage that may arise from the general use of these fire-places. It is observable, that, though these countries have been well inhabited for many ages, wood is still their fuel, and yet at no very great price; which could not have been, if they had not universally used stoves, but consumed it as we do, in great quantities, by open fires. By the help of this saving invention, our wood may grow as fast as we consume it, and our posterity may warm themselves at a moderate rate, without being obliged to fetch their fuel across the Atlantic; as, if pit-coal should not be here discovered, (which is an uncertainty,) they must necessarily do.

We leave it to the political arithmetician to compute how much money will be saved to a country by its spending two thirds less of fuel; how much labour saved in the cutting and carriage of it; how much more land may be cultivated; how great the profit by the additional quantity of work done, in those trades particularly that do not exercise the body so much, but that the workmen are obliged to run frequently to the fire to warm themselves; and to physicians, to say how much healthier thick-built towns and cities will be, now half suffocated with sulphureous smoke, when so much less of that smoke shall be made, and the air breathed by the inhabitants be consequently so much purer.

Franklin Stoves improved; as also the common Fire-place.

"The common chimney, or open fire-place, or grate; also the common open-stove, (called the Franklin stove, or fire-place,) says Mr. Pettibone, is very much improved, by placing an air-vessel upon it, and sometimes a hollow cylinder in place of a back log in it, or just above the fire. The flame and smoke, by passing round the air-vessel in a reverberatory manner, communicates their heat to the air in the air-vessel; which air is introduced into the air-vessel, from the exte-

rior atmosphere, as before described, and let into the room, or to an adjoining room, from the sides or top of the stove."

A Mr Sharp procured a patent, several years since, says Dr Willich, for certain improvements, which are calculated to obviate the inconveniences (of Franklin's stoves.) Thus, by adding a funnel to the top, these fire-places can be adapted to any chimnies; and, if the funnel be lengthened, it may be accommodated to libraries, ball-rooms, or other buildings, which have not the advantage of a chimney. Mr. Sharp's stove-grates are provided with a hollow base; in consequence of which, he is enabled to apply them, without any additional brick-work, more effectually to the purpose of heating rooms, than is practicable with those on Franklin's construction: at the same time, by his alterations in the air-box, a larger portion of air is introduced. Our limits permit us only to add, that Mr. Sharp's stove-grates may be accommodated to every building, whether public or private: and we refer the reader to his "*Account of the Air-stove-Grates*," &c. 8vo.

In June, 1796, a patent was granted to Mr. William Whittington, for his invention of a *Portable Baking Stove*. The patentee asserts, that the contrivance is calculated for baking all kinds of bread, particularly that prepared of oats, with a cheapness and facility not hitherto experienced. It may be manufactured from any metal, or even from clay, of any size or shape; and either with or without an oven: the door for supplying fuel, together with the pipe or flue for carrying off the smoke, may be fixed in any part of the stove. Besides, this machine may be used in any situation, whether on land or at sea; being easily portable, and requiring only one-fifth part of the fuel, consumed in the common way; as it may be easily heated with coke, coals, wood charcoal, or any other substance. For a more diffuse account of such contrivance, the reader will consult the 12th vol. of the *Repertory of Arts*, &c. where it is illustrated with an engraving.

A patent was likewise granted to Mr. Edward Walker, for a portable stove or kitchen; to facilitate the processes of cooking, or dressing provisions. The whole is manuactured of either cast or wrought iron; having a fire-place in its centre, which is inclosed by a door: beneath is an ash-hole; and on each side, there is a closet, one of which may be employed for baking; the other will contain two spits, with racks, &c. complete; the top may be used as a broiling-plate, heated by the same fire; while the smoke is carried off through an iron funnel, having a smoke-jack for the purpose of turning the spits. A more complete idea of this stove, may be obtained from the 15th vol. of the *Repertory of Arts and Sciences*, &c. where the specification is illustrated with an engraving.

Description of a kitchen stove; by Samuel Dickey. Communicated to the Agricultural Society of Philadelphia.

The general principles of this kitchen stove are,

1. Enclosing it with the pots connected with it, in some covering that is a non-conductor of heat, by which the speedy evaporation of the heat is prevented, and its power is concentrated more intensely upon the pots and ovens, used in cooking.

2. Drawing off the fire from the furnace of the stove, through openings in the stove plates, that may be closed at pleasure with sliding dampers, and by means of the covering that surrounds the stove, conveying it round pots set close to these openings, and returning it back upon the ovens, for the purpose of increasing the heat in them.

3. Allowing the fire to pass into the oven of the stove, through an opening in the bottom plate of the oven, immediately above the fire, so as to bear with all its force on a tea-kettle, or any small vessel set into the oven, for the purpose of boiling.

4. Receiving the heat into a large receptacle of sheet-iron placed above the stove, through which it may pass into the kitchen, for the purpose of warming it.

Every person who thinks upon the subject, is sensible of the vast waste of fuel, that takes place in cooking at an open fire. The introduction of a ten plate stove, is certainly economical, and adds much to the comfort of the kitchen. But still there is both a manifest expense and trouble, in keeping up two fires. One ought to serve all purposes. The stove or closed fire-place above described, does all the business of the kitchen with one fire, and a great saving of fuel, as the same heat that bakes and boils, is afterwards emitted to warm the kitchen, with nearly as good effect, as if it had performed no previous service. Besides the saving of wood, there is perhaps as great a saving of labour, by the facility with which the cooking business can be executed. The ovens are always warm, when there is fire in the stove. The fire can be turned off, and on the pots in an instant, without the trouble of moving them; and the cook is never exposed to the scorching heat of an open fire. This stove is set with the most advantage, in the fire-place of the kitchen.

The front of it extending about twelve inches out, from the breast of the chimney, so as to admit the apparatus for heating the kitchen, to stand out in front of the mantle. The throat of the chimney, should be stopped in winter, but furnished with a sliding shutter, to be opened occasionally, so as to allow the steam from the boiling pots to escape, without incommoding the kitchen.

For further information, see the Memoirs of the Society.

A Column Stove of Mr. Pettibone.

"For the purpose of ornament and utility, a stove, or rather a reservoir of heat, may be made of iron, earthen ware, brick or stone, to represent a column, in the centre of which, a pipe or flue is placed. The smoke is made to pass round the flue, from the bottom to the top, in a spiral or serpentine direction, which is done by means of bricks, so placed as to form a flue, to convey the smoke in this way. The stove or column, is furnished with tubes or boxes, as before described.—When the smoke has risen to the top of the column, it is carried off as in the common stove, or may be made to turn down through the centre of the air-flue. In this stove or reservoir, there is no appearance of pipes, or flues, from which circumstance, it may be so decorated as to render it ornamental."

A Dome Stove, of Mr. Pettibone.

"I have constructed a cylindrical stove, (it being composed of two or more cylinders, one within the other) standing perpendicular, or lying horizontally. When it is made to stand perpendicular, it resembles a dome. I sometimes made them to resemble a common coffee pot, of iron, brass,copper, potter's clay, earthen ware, glass, &c. excepting it has 2 spouts and no handle ; the spouts being opposite to each other, and serve as reservoirs or places to put in fuel, without disturbing the fire, as in the common stove. When lying horizontally, the fuel is put in at one end, or at the side or sides, (similar to a common air-furnace,) into the inner or outer cylinder; and the air being heated in the inner, or between the two cylinders. When the air is heated between the cylinders, the flame and smoke circulate in the inner one, and the warm air is suffered to escape at the top of the outward dome or cylinder, through ornamental figures,such as urns and blazers : to this dome is often applied the circular grate."

It may be proper to notice, that sundry other improvements have been made, for the purpose of warming rooms, cooking, and economizing fuel. Of the stoves for the purpose of the kitchen, none is more really useful than the improvement of Mr. Abbot, which is in general use throughout the city ; and which, when employed serves not only to perform the domestic uses of the kitchen, almost at one and the same time, (from the arrangement of the pots, &c.) but is also considerable saving in fuel. See FUEL, economy of.

STUCCO.—Higgins's patent stucco is a compound of 14 or 15 lbs. of choice lime, 14 lbs. of bone ashes, finely pulverised, and 98 lbs. of clean sand, fine or coarse, according to the work intended, mixed up into mortar as quickly as possible with lime water, and used as soon as made. See CEMENT.

SUBLIMATION. Sublimation is in the dry way what distillation is in the moist. Thus, if a small quantity of sal ammoniac is put into a flask, and heat is applied at the bottom; the entire salt rises in the form of white smoke, and condenses in the upper part of the flask in the form of minute crystalline particles, which is a *sublimate.*

Sublimation is conveniently performed in the small way in common flasks, especially the Florence oil flasks, which being of green glass, bear a low red heat very well.

In the large way, as in the making of camphor or sal ammoniac, it is also performed in very large glass globes or earthen cucurbites, or sometimes. though rarely, in a series of earthen vessels, called *Aludels.*

SUGAR, is a constituent part of vegetables, existing in considerable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, skirret, parsneps, and dried grapes. The process of this chemist consisted in digesting these roots, rasped or finely divided, in alcohol This fluid dissolves the sugar, and leaves the extractive matter untouched, which falls to the bottom.

In Canada the inhabitants extract sugar from the maple. At the commencement of spring they heap snow in the evening at the foot of the tree, in which they previously make apertures for the passage of the returning sap. Two hundred pounds of this juice afford by evaporation fifteen of a brownish sugar. The quantity prepared annually amounts to fifteen thousand weight. See MAPLE SUGAR.

From frequent trials of this sugar, it does not appear to be in any respect inferior to that of the West Indies. It is pre-

pared at a time of the year when neither insect nor the pollen of plants, exists to vitiate it, as is the case with common sugar. From calculations grounded on facts it is ascertained, that America is now capable of producing a surplus of one-eighth more than its own consumption; that is, on the whole, about 135,000,000 pounds; which in the country may be valued at fifteen pounds weight for one dollar.

The Indians likewise extract sugar from the pith of the bamboo.

The great sources of sugar are, the common juice or sap of plants, as in the sugar-cane, and maple sap; the ripe fruit, as in the grape, date, fig, in all of which it exudes and effloresces on the surface, when kept dry; and the root (though in much smaller quantity) as in the beet and parsnip. It is also elaborated during the first germination of most grains, particularly barley, as is seen in the process of malting.

The Cochin Chinese, prepare a very excellent moist sugar remarkably cheap, by a very simple process which acts similar to the claying. The grained sugar after the gross syrup has drained off from it, and it has become considerably solid, is placed in layers of about an inch thick, under layers of equal dimensions of the herbaceous trunk of the plantain tree, the watery juices exuding from which, act like claying, and leave the sugar very white, and porous like a honeycomb. It is sufficiently pure to dissolve in water without leaving any sediment.

The beet has lately been much cultivated in Germany, for the purpose of extracting sugar from its root. For this the roots are taken up in autumn, washed clean, wiped, sliced lengthwise, strung on threads, and hung up to dry. From these the sugar is extracted by maceration in a small quantity of water; drawing off this upon fresh roots, and adding fresh water to the first roots, which is again to be employed the same way, so as to get out all their sugar, and saturate the water as much as possible with it, This water is to be strained and boiled down for the sugar.

Some merely express the juice from the fresh roots, and boil this down; others boil the roots; but the sugar extracted in either of these ways is not equal in quality to the first.

Professsor Lampadius obtained from 110 lbs. of the roots, 4 lbs. of well grained white powder sugar; and the residuum afforded 7 pints of a spirit resembling rum. Achard says that about a ton of roots produced him a hundred pounds of raw sugar, which gave fifty-five pounds of refined sugar, and twenty-five pounds of treacle.

Sugar is made in large quantities in France from this source.

The skirret root was treated in the following manner without alcohol, with a view of extracting the sugar. A quantity of it was chopped small, bruised in a mortar, and the juice expressed through a cloth bag, and the pulp was again moistened with water, and expressed to get out all the saccharine liquor The whole liquor was then kept at rest for forty-eight hours, in a cool cellar, by which most of the feculence subsided, and the clear liquor was carefully drawn off. The author lays much stress on this part of the process, which, if it is not done properly, considerably hinders the subsequent production of the sugar. The clear liquor was then heated in a copper pan, clarified with white of egg, and boiled down to the consistence of thick syrup, and kept in this state for about six months in a warm place, by which it concreted into a semi-fluid crystalline mass, composed of impure crystals of sugar, and a good deal of syrup. The whole mass was then a little warmed, to give the syrup a little more fluidity, and poured into a funnel-shaped vessel of tinned iron, with holes at the sides and bottom, and set by, in a warm place; by which, after a considerable time, the impure uncongealable syrup slowly filtered to the bottom, leaving the purer saccharine part in the form of a brown granular mass. The latter was then redissolved in water, again clarified with white of egg, strained, boiled with a little lime, again strained, and then evaporated to a thick consistence, and stirred till cold. A sugary viscid mass still purer than the last was thus obtained, which, on being kept for a week in a funnel-shaped pot with a single hole at bottom, plugged up, congealed into a grained sugar equal to good muscovado, from which a syrup separated and dropped through when the plug was withdrawn.

Such is the process of this chemist to obtain a sugar from the skirret root, and he proceeded in the same manner with the white and red beet root, and with the same success. He further observes, that he rasped the beet roots, they being harder than the skirrett, that the mucilaginous deposit from the beets was browner and less copious than from the skirret: the sugar from the white beet was the most abundant and the purest, and that from the red beet was the least so. The mucilage or sediment from the skirret washed with cold water and purified, yielded a very good white farina.

But the sugar which is so universally used is afforded by the sugar-cane (arundo saccharifera) which is raised in tropical climates. When this plant is ripe, it is cut down, and crushed by passing it between iron cylinders placed perpendicularly, and moved by water or animal strength. The juice which flows out by this strong pressure is received in a shallow trough placed beneath the cylinder. This juice is called in the French sugar-colonies vesou; and the cane, after having undergone this pressure, is called begasse. The juice is more or less saccharine, according to the nature of the soil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the soil or the weather has been humid; and in contrary circumstances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood ashes and lime. It is subjected to the same operation in three several boilers, care being taken to remove the scum as it rises. In this state it is called syrup; and is again boiled with lime and alum till it is sufficiently concentrated, when it is poured into a vessel called the cooler. In this vessel it is agitated with wooden stirrers, which breaks the crust as it forms on the surface. It is afterwards poured into casks, to accelerate its cooling, and while it is still warm, it is conveyed into barrels standing upright over a cistern, and pierced through their bottoms with several holes stopped with cane. The syrup, which is not condensed, filters through these canes into the cissern beneath, and leaves the sugar in the state called coarse sugar, or muscovado. This sugar is yellow and fat, and is purified in the islands in the following manner: The syrup is boiled, and poured into conical earthen vessels, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The syrup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure syrup may run out. The base of these sugar loaves is then taken out, and white pulverized sugar substituted in its stead; which being well pressed down, the whole is covered with clay, moistened with water. This water filters through the mass, carrying the syrup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called fine syrup. Care is taken to moisten and keep the clay to a proper degree of softness, as it becomes dry. The sugar loaves are afterward taken out, and dried in a stove for eight or ten days; after which they are pulverized, packed, and exported to Europe, where they are still farther purified.

The operation of the French sugar refiners consists in dissolving the cassonade or clayed sugar, in lime water. Bullocks' blood is added, to promote the clarifying; and, when the liquor begins to boil, the heat is diminished, and the scum carefully taken off. It is in the next place concentrated by a brisk heat; and, as it boils up, a small quantity of butter is thrown in, to moderate its agitation. When the boiling is sufficiently effected, the fire is put out, the liquor is poured into moulds, and agitated, to mix the syrup together with the grain sugar already formed. When the whole is cold, the moulds are opened, and the loaves are covered with moistened clay, which is renewed from time to time till the sugar is well cleansed from its syrup. The loaves being then taken out of the moulds, are carried to a stove, where they are gradually heated to 145° Fahr. They remain in this stove eight days, after which they are wrapped in blue paper for sale.

The several syrups, treated by the same methods, afford sugars of inferior qualities; and the last portion, which no longer affords any crystals, is sold by the name of molasses. The Spaniards use this molasses in the preparation of sweetmeats.

A solution of sugar, much less concentrated than that we have just been speaking of, when at rest lets fall crystals, which affect the form of tetrahedral prisms, terminated by dihedral summits, and known by the name of sugar-candy.

The preceding account of the manufacture of sugar in the colonies is chiefly extracted from Chaptal. The following more ample account is taken from Edwards's History of the West Indies, the authority of which is indubitable.

The sugar-cane is a jointed reed, which terminates in leaves or blades, the edges of which are finely and sharply serrated. The body of the cane, though brittle, is strong, and when ripe, is of a fine straw colour inclinable to yellow. It likewise contains a soft pithy substance, which is replete with juice of a very agreeable taste. The general distance between each joint of the cane is from one to three inches in length, and from half an inch to an inch in diameter; and the general height (the flag part being excluded) is from three feet and a half to seven feet

In very rich lands, too, the stool or root has been known to put forth upward of one hundred suckers or shoots.

To bring a plant of this rank and succulent nature to perfection, no land can be too rich; and the ashy loam of St. Christopher's appears to be the best soil hitherto known, for the production of sugar of the finest quality, and in the largest proportion. The next to this in excellence is the soil which in Jamaica is called brick-mould. It is a deep, warm, and mellow, hazel earth, which is easily worked, and which in the wettest season seldom requires trenching. In a very fine season, plant canes (which are those of the first growth) have been known, in this soil, to yield two tons and a half of sugar per acre. The black mould of several varieties may be reckoned after this. The best is the deep black earth of Barbadoes, Antigua, and some other of the windward islands; but there is a species of this mould in Jamaica, that is perhaps not in the least inferior to it, which abounds with limestone and flint, on a substratum of soapy marle. Black mould on clay is more common; and, when properly pulverized and manured, becomes very productive, and may be said to be inexhaustible. But there are few soils, that produce a greater return of refined sugar, than a peculiar sort of land on the north side of Jamaica, and particularly in the parish of Trelawney. This land is generally of a red colour, is every where remarkable when first turned up for a glossy surface, and when wetted, stains the fingers like paint. It appears to consist of a native earth or pure loam, with a mixture of clay and sand; and though deep, it is by no means heavy, and is naturally dry. Hence, as its fertility is destroyed when too much exposed to the burning influence of a tropical sun, the system of husbandry, where this soil abounds, chiefly depends on what is called ratoon canes. Ratoons are the suckers, that spring from the roots or stools of the canes that have been previously cut for sugar, and are generally ripe in twelve months. Plant-canes, or canes of the first growth, are the immediate produce of the original germs placed in the ground, and require from fifteen to seventeen months to bring them to maturity. The first yearly returns from their roots are called first ratoons, the second year's growth second ratoons, and so on, according to their age. The common yielding too of this cane-land, on an average, is seven hogsheads of 16 cwt. to ten acres, which are cut every year.

The crop time in the sugar islands is the season of festivity, both to man and beast; for so agreeable to the taste, and so nourishing to the corporeal frame, is the juice of the cane, that every animal derives health and vigour from its use. Such of the negroes as were meagre and sickly become surprisingly altered for the better in a few weeks after the mill is set in action. The labouring horses, oxen, and mules, though almost constantly at work during this season, yet, in consequence of eating plentifully of the green tops of this invigorating plant, and being ing indulged with some of the scummings from the boiling-house, improve more than at any other period of the year. Even pigs and poultry fatten on the refuse. In short, during crop-time, plenty and industrious cheerfulness every where prevail in such a high degree on a well-regulated plantation, as considerably to soften the hardships of slavery, and induce an impartial spectator to conclude, that the miseries of life are sometimes exaggerated through the delusive medium of fancy.

Such planters, as are not fortunately furnished with the means of grinding their canes by water, are at this season frequently impeded by the failure or insufficiency of their mills; for though a sugar-mill is a very simple contrivance, yet great force is requisite to make it vanquish the resistance which it necessarily meets with. It principally consists of three upright iron rollers or cylinders, from thirty to forty inches in length, and from twenty to twenty-five inches in diameter; and the middle one, to which the moving power is applied, turns the other two by means of cogs. The canes, which are previously cut short and tied into bundles, are twice compressed between these rollers; for, after they have passed through the first and second rollers, they are turned round the middle one by a piece of frame work of a circular form, which is called in Jamaica the dumb-returner, and forced back through the second and third. By this operation they are squeezed completely dry, and sometimes even reduced to powder. The cane-juice is received in a leaden bed, and thence conveyed into a vessel called the receiver. The refuse, or macerated rind of the cane, which is called cane-trash, serves for fuel to boil the liquor.

The juice from the mill usually contains eight parts of pure water, one part of sugar, and one part made up of gross oil, and mucilage, with a portion of essential oil. The proportions are taken at a medium; for some juice has been so rich as to make a hogshead of sixteen hundred weight of sugar from thirthen hundred

gallons, and some is so watery as to require more than double that quantity. The richer the juice is, the less it abounds with redundant oil and gum; so that very little knowledge of the contents of any other quantity can be obtained by the most exact analysis of any one quantity of juice.

The following matters are, likewise, usually contained in cane-juice. Some of the green tops, which serve to tie the cane in bundles, are often ground in, and yield a raw acid juice exceedingly disposed to ferment and render the whole liquor sour. Beside these, they grind in some pieces of the ligneous part of the cane, some dirt, and lastly, a substance of some importance, which may be called the crust. This substance is a thin black coat of matter that surrounds the cane between the joints, beginning at each joint, and gradually growing thinner the farther from the joint upwards, till the upper part between the joints appears entirely free from it and resumes its bright yellow colour. It is a fine black powder, that mixes with the clammy exsudations from the cane; and as the fairness of the sugar is one symptom of its goodness, a small quantity of this crust must very much prejudice the commodity.

The sugar is obtained by the following process: The juice or liquor runs from the receiver to the boiling-house, along a wooden gutter lined with lead. In the boiling-house, it is received into one of the copper pans or caldrons, called clarifiers. Of these there are generally three; and their dimensions are determined by the power of supplying them with liquor. There are water-mills, that will grind with great facility sufficient for thirty hogsheads of sugar in a week. Methods of quick boiling cannot be dispensed with on plantations thus fortunately provided; for otherwise the cane liquor would unavoidably become tainted before it could be exposed to the fire. The purest cane-juice will not remain twenty minutes in the receiver without fermenting. Hence, clarifiers are sometimes seen of one thousand gallons each. But on plantations that during crop-time make from fifteen to twenty hogsheads of sugar a week. three clarifiers of three or four hundred gallons each, are sufficient. The liquor, when clarified, may be drawn off at once, with pans of this size, and there is leisure to cleanse the vessels every time they are used. Each clarifier is furnished either with a syphon or cock for drawing off the liquor. It has a flat bottom, and is hung to a separate fire, each chimney having an iron slider, which, when shut, causes the fire to be extinguished through want of air.*

As soon as the stream from the receiver has filled the clarifier with fresh liquor, and the fire is lighted, the temper, which is generally Bristol white-lime in powder, is stirred into it. This is done, in order to neutralize the superabundant acid, and to get rid of which is the great difficulty in sugar-making. Alkali, or lime, generally effects this; and at the same time part of it is said to become the basis of the sugar. Mr. Edwards affirms, that it affects both the smell and taste of the sugar. It falls to the bottom of the pans in a black insoluble matter, which scorches the bottom of the vessels, and cannot without difficulty be detached from them. But in order that less of the lime may be precipitated to the bottom, little more than half a pint of Bristol lime should be allowed to every hundred gallons of liquor, and Mr Bousie's method of dissolving it in boiling water previous to mixing it with the cane-juice should be adopted.†

As the force of the fire increases, and

* The clarifiers are generally placed in the middle or at one end of the boiling-house. When they are placed at one end, the boiler called the teache is placed at the other, and three boilers are usually ranged between them. The teache commonly holds from 70 to 100 gallons, and the boilers between the clarifiers and teache diminish in size from the first to the last. But when the clarifiers are in the middle, there is generally a set of three boilers on each side, which in effect form a double building-house. This arrangement is very necessary on large estates.

† Mr. Bousie, to whom, for his improvements in the art of sugar-boiling, the Assembly of Jamaica gave 1,000*l.* in a paper which he distributed among the members, recommends vegetable alkali, or ashes of wood, such as pimento tree, dumb cane, fern tree, cashew, or logwood, as affording a better temper than quick-lime. Afterward, however, he was convinced, that sugar formed on the basis of fixed alkaline salts never stands the sea, unless some earth is united to the salts. Such earth as approaches nearest to the basis of alum, Mr. Edwards thinks, would be most proper; and it deserves to be inquired how far a proper mixture of vegetable alkaline salts and lime might prove a better temper than either lime or alkaline salts alone. In some parts of Jamaica, where the cane-liquor was exceedingly rich, Mr. Bousie made very good sugar without a particle of temper.

the liquor grows hot, a scum is thrown up, which is formed of the gummy matter of the cane, with some of the oil, and such impurities as the mucilage is able to entangle. The heat is now suffered to increase gradually till it nearly rises to the heat of boiling water. The liquor, however, must by no means be suffered to boil. When the scum begins to rise into blisters, which break into white froth, and generally appear in about forty minutes, it is known to be sufficiently heated. Then the damper is applied, and the fire extinguished; and if circumstances will admit, the liquor after this is suffered to remain a full hour undisturbed. In the next place, it is carefully drawn off, either by a siphon, which draws up the clear fluid through the scum, or by means of a cock at the bottom. In either case, the scum sinks down without breaking as the liquor flows; for its tenacity prevents any admixture. The liquor is received into a gutter or channel, which conveys it to the evaporating boiler, commonly called the grand copper; and if produced at first from good and untainted canes, it will then appear almost transparent.

In the grand or evaporating copper, which should be sufficiently large to receive the net contents of one of the clarifiers, the liquor is suffered to boil, and the scum, as it rises, is continually taken off by large scummers, till the liquor becomes finer and somewhat thicker. This operation is continued till the subject is so reduced in quantity, that it may be contained in the next or second copper, into which it is then ladled. The liquor is now almost of the colour of Madeira wine. In the second copper the boiling and scumming are continued; and if the subject be not so clean as is expected, lime-water is thrown into it. This addition not only serves to give more temper, but likewise to dilute the liquor, which sometimes thickens too fast to permit the feculencies to rise in the scum. When the froth in boiling arises in large bubbles, and is not much discoloured, the liquor is said to have a favourable appearance in the second copper. When in consequence of such scumming and evaporation the liquor is again so reduced, that it may be contained in the third copper, it is ladled into it, and so on to the last copper, which is called the teache. This arrangement supposes four boilers or coppers, beside the three clarifiers.

In the teache the subject undergoes another evaporation, till it is supposed boiled enough to be removed from the fire. This operation is usually called striking, *i. e.* ladling the liquor, which is now exceeding thick, into the cooler.

The cooler, of which there are generally six, is a shallow wooden vessel, about eleven inches deep, seven feet in length, and from five to six feet wide. A cooler of this size holds a hogshead of sugar. Here the sugar grains; *i. e.* as it cools, it runs into a coarse irregular mass of imperfect crystals, separating itself from the molasses. From the cooler it is taken to the curing-house, where the molasses drains from it.*

But here it may be proper to notice the rule for knowing when the subject is fit to be ladled from the teache to the cooler. Many of the negro boilers, from long habit, guess accurately by the eye alone, judging by the appearance of the grain on the back of the ladle; but the practice generally adopted is to judge by what is called the touch, *i. e.* taking up with the thumb a small portion of hot liquor from the ladle, and, as the heat diminishes, drawing with the forefinger the liquid into a thread. This thread will suddenly break and shrink from the thumb to the suspended finger, in different lengths, according as the liquor is more or less boiled. A thread of a quarter of an inch long generally determines the proper boiling height for strong muscovado sugar.†

The curing-house is a large airy build-

* It is necessary to observe in this place, that, in order to obtain a large-grained sugar, it must be suffered to cool slowly and gradually. If the coolers be too shallow, the grain is injured in a surprising manner.

† The vessel called the teache probably derived its name from this practice of trying by the touch (tactio). Some years ago, John Proculus Baker, Esq. barrister at law, recommended to the public a method more scientific and certain, in a treatise which he published in 1775, entitled, An Essay on the Art of making Muscovado Sugar. It is as follows: "Provide a small thin pane of clear crown glass, set in a frame, which I would call a tryer; on this drop two or three drops of the subject, one on the other, and carry your tryer out of the boiling-house into the air. Observe your subject, and more particularly whether it grain freely, and whether a small edge of molasses separate at the bottom. I am well satisfied, that a little experience will enable you to judge what appearance the whole skip will put on when cold, by this specimen, which is also cold. This method is used by chemists, to try evaporated solutions of all other salts: it may seem therefore somewhat strange, it has not been long adopted in the boiling-house."

ing, provided with a capacious molasses cistern, the sides of which are sloped and lined with terras, or boards. A frame of massy joist-work without boarding is placed over this cistern; and empty hogsheads without headings are ranged on the joists of this frame. Eight or ten holes are bored in the bottoms of these hogsheads, and through each of the holes the stalk of a plantain leaf is thrust six or eight inches below the joists, and long enough to stand upright above the top of the hogshead. Into these hogsheads the mass from the cooler is put, which is called potting; and the molasses drains through the spongy stalk, and drops into the cistern, whence it is occasionally taken for distillation. In the space of three weeks, the sugar becomes tolerably dry and fair. It is then said to be cured, and the process is finished.

Sugar thus obtained is called muscovado, and is the raw material whence the sugar-bakers chiefly make their loaf or refined lump. There is another sort, which was formerly much used for domestic purposes, and was generally known by the name of Lisbon sugar In the West-Indies it is called clayed sugar; and the process of making it is as follows:

A quantity of sugar from the cooler is put into conical pots or pans, which the French call formes, with the points downward, having a hole about half an inch in diameter at the bottom, for the molasses to drain through, but which at first is closed with a plug. As soon as the sugar in these pots is cool, and becomes a fixed body, which is known by the middle of the top falling in, the plug is taken out, and the pot placed over a large jar, intended to receive the sirup or molasses that drains from it. In this state it is left as long as the molasses continues to drop, when a stratum of clay is spread on the sugar, and moistened with water. This, imperceptibly oozing through the pores of the clay, dilutes the molasses, in consequence of which more of it comes away than from sugar cured in the hogshead, and the sugar of course becomes so much whiter and purer. According to Sloane, the process was first discovered in Brasil, by accident "A hen," says he, "having her feet dirty, going over a pot of sugar, it was found under her feet to be whiter than elsewhere." The reason assigned why this process is not universally adopted in the British sugar-islands is this, that the water which dilutes and carries away the molasses, dissolves and carries with it so much of the sugar, that the difference in quality does not pay for the difference in quantity. It is probable, however, that the French planters are of a different opinion; for upwards of four hundred of the plantations of St. Domingo have the necessary apparatus for claying, and actually carry on the system.

A valuable and simple process has lately been discovered by Edward Howard, Esq. F. R. S. for refining sugar, which promises to be of great advantage. The following is an outline of the process, but a more detailed account of it may be expected to be published by that gentleman himself:—"Take brown sugar, sift it through a coarse sieve, then put it lightly into a conical vessel having holes at the bottom (like a coffee machine). Then mix some brown sugar with white syrup, that is, syrup of refined sugar, to the consistency of batter or thick cream, and pour it gently on the top of the sugar in the vessel till the surface is covered. The syrup will soon begin to percolate, and leave the surface in a state which will allow more syrup to be poured upon it, which is to be done carefully. The treacle will be found to come out at the bottom, having left the whole mass perfectly white. The first droppings are to be kept apart, as the last will serve to begin another operation. The sugar is now in a pure state, except as to its containing insoluble matter, which may of course be separated by solution in water.—The clarification is to be performed by the best pipe-clay and fuller's earth, and the addition of neutral alum, if lime be previously contained therein; the whole to be agitated together; and, if expedition be required, it should be heated to the boiling point: the feculencies will then subside. The brown syrup may also be much improved by means of tannin and the above earths. To make the sugar into snow-white powder, it is only necessary to evaporate the clarified solution to dryness on a water-bath. To make loaves, the common methods may be resorted to, or the syrup drawn off by exhaustion, or small grains may be made according to M. Du Trone's process, *with much water*, and these grains may be cemented by hot concentrated syrup."

Sugar is very soluble in water, and is a good medium for uniting that fluid with oily matters. It is much used for domestic purposes, and appears upon the whole to be a valuable and wholesome article of food, the uses of which are most probably restricted by its high price. This price may in a certain degree arise from the nature of the article, and its original cost; but is no doubt in a great measure owing to the inhuman and wasteful culture by slaves, and the absurd principles of Euro-

pean colonization, duties, draw-backs, and bounties, which have the effect to create unnatural monopolies, and to prevent commerce from finding its level. This is eminently the case with regard to the British West-India islands, and their produce.

One very extensive use of sugar and saccharine juices consists in the formation of ardent spirit, an article which, all things considered, is perhaps a curse to society. The wines or beers of pure sugar ferment so rapidly, that they can scarcely be kept, but are for the most part made for immediate use. We do not know of any beer of pure sugar, which is stored and kept for sale; though it is said to enter largely into the composition of porter; and a kind of beer for present use is made by fermenting treacle and water in many country places See ALCOHOL.

Mr. Haussman says, that when he used nitric acid of 40° to convert sugar into oxalic acid, either of its full strength or diluted with equal parts of water, he constantly obtained a little greasy matter, when he conducted the process in the large way on a vapour bath.

On treating the same sugar three times successively with equal portions of this acid, either concentrated or diluted, the first portion occasions a brown colour, and produces the smell of burnt sugar: and when the action of the nitric acid has ceased, some of this grease is perceived swimming at the top; and it appears to be farther increased by the successive addition of the other two portions of acid, which cause the brown colour and smell of burnt sugar to disappear, forming a great abundance of oxalic acid, and a small quantity of the malic and citric acids. He adds, that, perhaps, if the gasses were collected, we should find a little acetic acid also.

To satisfy himself whether the sugar gave rise to the formation of the grease, he examined one of the largest sized sugar-loaves, which he commonly used. He divided it into two equal portions, the first consisting of the outer part of the loaf, the second of the inner. Each of these portions he boiled for a few minutes in three times its weight of water. No grease swam on either of these solutions of sugar, after they were cold; but as they were not very clear, he began to suspect, that, the syrup for common sugar being clarified with bullocks' blood by the sugar-bakers, the gelatinous part of this animal substance unites in some measure with the particles of sugar by a forced and confused crystallization, and when acted upon by nitric acid may give rise to the separation of grease. He was not long before he satisfied himself, that his suspicion was just; for, on making oxalic acid with some fine white sugar-candy, and at the same time with the finest loaf-sugar he could procure, neither of these showed any signs of grease.

SUGAR OF LEAD. See LEAD.

SUGAR OF MILK See MILK.

SUGAR, MAPLE. See MAPLE SUGAR.

SULPHUR, or brimstone, is a well known, hard, brittle, inflammable substance, of an opake yellow colour. It is found more or less pure in the neighbourhood of volcanoes; where most probably it is always expelled from some previous state of combination, by the heat of subterraneous fires. It is a very common ingredient, in a great variety of minerals and ores; but it extracted for sale chiefly, from a stone called pyrites.

In order to obtain sulphur from pyrites, this mineral ought to be exposed to a heat sufficient to sublime the sulphur, or to make it distil in vessels, which must be close to prevent its burning.

Sulphur is extracted from pyrites, at a work at Schwartzemberg, in Saxony, in the high country of the mines, and in Bohemia, at a place called Alten-Sattel.

The furnaces employed for this operation are described by Macquer. They are oblong, like vaulted galleries; and in the vaulted roofs, are made several openings. These are called furnaces, for extracting sulphur.

In these furnaces are placed earthenware tubes, filled with pyrites broken into pieces, of the size of small nuts. Each of these tubes, contains about fifty pounds of pyrites. They are placed in the furnace almost horizontally, and have scarcely more than an inch of descent. The ends, which come out of the furnace five or six inches, become gradually narrower. Within each tube, is fixed a piece of baked earth, in form of a star, at the place where it begins to become narrower, in order to prevent the pyrites from falling out or choking the mouth of the tube.—To each tube is fitted a receiver, covered with a leaden plate, pierced with a small hole to give air to the sulphur. The other end of the tube, is exactly closed. A moderate fire is made with wood, and in eight hours the sulphur of the pyrites, is found to have passed into the receivers.

The residuum of the pyrites, after the distillation, is drawn out at the large end, and fresh pyrites is put in its place. From

this residuum, which is called burnings of sulphur, sulphat of iron is extracted. See SULPHURIC ACID.

The eleven tubes into which are put, at three several distillations, in all nine quintals, or 900 lbs. of pyrites, yield from 100 to 150 lbs. of crude sulphur, which is so impure, as to require purification by a second distillation.

This purification of crude sulphur is also done in a furnace, in form of a gallery, in which five iron cucurbits are arranged on each side. These cucurbits are placed in a sloping direction, and contain about eight quintals and a half of crude sulphur. To them are luted earthen tubes, so disposed, as to answer the purpose of capitals. The nose of each of these tubes is inserted into an earthen pot, called the forerunner. This pot has three openings; namely, that which receives the nose of the tube; a second smaller hole, which is left open to give air; and a third in its lower part, which is stopped with a wooden peg.

When the preparations are made, a fire is lighted about seven o'clock in the evening, and is a little abated, as soon as the sulphur begins to distil At three o'clock in the morning, the wooden pegs, which stop the lower holes of the forerunners, are for the first time drawn out, and the sulphur flows out of each of them into an earthen pot, with two handles, placed below for its reception. In this distillation the fire must be moderated, and prudently conducted; otherwise, less sulphur would be obtained, and it would also be of a gray colour, and not of a fine yellow, which it ought to have when pure. The ordinary loss in the purification of eight quintals of crude sulphur, is, at most one quintal.

When the sulphur is all flowed out, and has cooled a little in the earthen pots, it is cast into moulds made of beech-tree, which had been previously dipped in water, and set to drain. As soon as the sulphur is cooled in the moulds, they are opened, and the cylinders of sulphur are taken out, and put up in casks. These are called roll-brimstone.

As sulphur exists not only in pyrites, but in most metallic minerals, it is evident that it might be obtained by works in the large way, from the different ores which contain much of it, and from which it must be separated, previously to their fusion: but as sulphur is of little value, the trouble of collecting it from ores is seldom taken. Smelters are generally satisfied with freeing their ores from it, by exposing them to a fire sufficient to expel it. This operation is called torrefaction, or roasting of ores. See ORES.

There are, however, ores which contain so much sulphur, that part of it is actually collected, in the ordinary operation of roasting, without much trouble for that purpose. Such is the ore of Ramelsberg, in the county of Hartz.

This ore, which is of lead containing silver, is partly very pure, and partly mixed with cupreous pyrites and sulphur; hence it is necessary to roast it.

The roasting is performed by laying alternate strata of ore and wood, upon each other in an open field, taking care to diminish the size of the strata as they rise higher, so that the whole mass shall be a quadrangular pyramid truncated above, the base of which is about thirty-one feet square. Below, some passages are left open, to give free entrance to the air; and the sides and top of the pyramid, are covered over with small ore, to concentrate the heat, and make it last longer. In the centre of this pyramid there is a channel, which descends vertically from the top to the base. When all is properly arranged, ladlefuls of red-hot scoria from the smelting furnace, are thrown down the channel, by which means the shrubs and wood, placed below for this purpose, are kindled, and the fire is from them, communicated to all the wood of the pile, which continues burning till the third day. At that time the sulphur of the mineral, becomes capable of burning spontaneously, and of continuing the fire, after the wood is consumed.

When this roasting has been continued fifteen days, the mineral becomes greasy, that is, it is covered over with a kind of varnish: twenty or twenty-five holes or hollows, are then made in the upper part of the pile, in which the sulphur is collected. From these cavities the sulphur is taken out, thrice every day, and thrown into water. This sulphur is not pure, but crude, and is therefore sent to the manufacturers of sulphur, to be purified in the manner above related.

As this ore of Ramelsberg is very sulphureous, the first roasting, which we are now describing, lasts three months; and during this time, if much rain have not fallen, or if the operation have not failed by the pile falling down or cracking, by which the air has so much free access, that the sulphur is burnt and consumed, from ten to twenty quintals of crude sulphur, are by this method collected.

The sulphur of this ore, like that of most others, was formerly neglected, till in the year 1570, a person employed in

the mines called Christopher Sauder, discovered the method of collecting it, nearly as it is done at present.

Metallic minerals are not the only substances, from which sulphur is extracted; this matter is diffused in the earth in such quantities, that the metals cannot absorb it all. Some sulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanoes, in caverns, and in mineral waters. Such are the opake kind, called virgin sulphur: the transparent kind, called sulphur of Quito; and the native flowers of sulphur, as those of the waters of Aix-la-Chapelle. It is also found mixed with different earths. Here we may observe, that all those kinds of sulphur, which are not mineralized by metallic substances, are found near volcanoes, or hot mineral waters, and consequently in places, where nature seems to have formed great subterranean laboratories, in which sulphureous minerals may be analysed and decomposed, and the sulphur separated, in the manner in which it is done in the small way, in our works and laboratories. However this may be, certainly one of the best and most famous sulphur mines in the world, is that called Solfatara.

The Abbé Nollet has published, in the Memoirs of the Academy, some interesting observations upon this subject, of which Macquer gives the following abridgement.

Near Puzzoli, in Italy, is that great and famous mine of sulphur and alum, called at present Solfatara. It is a small oval plain, the greatest diameter of which is about 400 yards, raised about 300 yards above the level of the sea. It is surrounded by high hills and great rocks, which fall to pieces, and the fragments of which form very steep banks. Almost all the ground is bare and white, like marl; and is every where sensibly warmer than the atmosphere, in the greatest heat of summer; so that the feet of persons walking there, are burnt through their shoes. It is impossible not to observe the sulphur there, for every where may be perceived by the smell, a sulphureous vapour, which rises to a considerable height, and gives reason to believe, that there is a subterraneous fire below, from which that vapour proceeds.

Near the middle of the field, there is a kind of basin, three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, the waters of which seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapours rising from the bottom of the lake, which, being set in motion by the action of subterranean fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapours are exhaled. Persons who have the itch, come to these pits and receive the vapours, in order to be cured. Finally, there are some deeper excavations, whence a soft stone is procured, which yields sulphur.

From these cavities vapours exhale, and issue out with a noise, which are nothing else, than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm weather the vapours may be evidently seen to rise twenty-five or thirty feet, from the surface of the earth.

The vapours, attaching themselves to the side of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access.

In entering the Solfatara, there are warehouses and buildings erected for the refining of sulphur.

Under a great shed, supported by a wall behind, open on the other three sides, sulphur is procured by distillation, from the soft stones we mentioned above.—These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow colour; but the workmen say they have lost their strength, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained, from the stones which are dug out of the ground.

These last-mentioned stones are broken into lumps, and put into pots of earthenware, containing each about twenty quarts. The mouths of these pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the same earth, well luted, and are arranged in two parallel lines, along two brick walls, which form the two sides of a furnace. The pots are placed within these walls; so that the centre of each pot, is in the centre of the thickness of the wall, and one end of the pots, overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of these pots are placed; that is, five in each of the two walls, which form the two sides of the furnace. Betwixt these walls there is 15 or 18 inches;

which space is covered by a vault, resting on the two walls. The whole forms a furnace seven feet long, two feet and an half high, open at one end, and shut at the other, excepting a small chimney, through which the smoke passes.

Each of these pots has a mouth in its upper part without the furnace, in order to admit a tube of 18 lines in diameter, and a foot in length, which communicates with another pot of the same size placed without the building, and pierced with a round hole in its base, of 15 or 18 lines diameter. Lastly, to each of these last-mentioned pots, there is a wooden tub placed below, on a bench made for this purpose.

Four or five of these furnaces are built under one shed. Fires are kindled in each of them at the same time; and they are thrown down after each distillation, either that the pots may be renewed, or that the residuum may be more easily taken out.

The fire, being kindled in the furnace, heats the first pots, containing the sulphureous stones. The sulphur rises in fumes into the upper part of the pot, whence it passes through the pipe of communication, into the external vessel.—There the vapours are condensed, become liquid, and flow through the hole below into the tub, from which the sulphur is easily turned out, because the form of the vessel, is that of a truncated cone, the narrower end of which is placed below; and because the hoops of the tub are so fastened, that they may be occasionally loosened. The mass of sulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and cast into rolls, as we receive it.

For accurate purposes, sublimation is necessary, to deprive sulphur of the accidental impurities it may contain. This may be done in an earthen cucurbit set on a sand-bath, with a head properly adapted. The sulphur rises by a very gentle heat, little more than is sufficient to melt it; and the fine sublimate thus obtained, is called flowers of brimstone, or of sulphur.

Water has no immediate action on sulphur.

Sulphur is soluble in alcohol.

Sulphuric ether by long digestion, takes up about one-thirteenth of its weight in the light, and only a seventeenth in the dark.

The combinations of sulphur with earths or alkalies, were formerly called hepars, or livers of sulphur, from their colour; a name which has been changed for that of sulphurets. There is no perceptible action between sulphur and silex. Alumine has very little action upon it, in the direct way; but lime unites readily with it. If fresh, quicklime and flowers of sulphur be mixed, and water be added a little at a time, the heat of the lime will be sufficient to produce the combination. On addition of more water, it becomes reddish, and emits a fœtid smell, of rotten eggs, which is common to all the sulphurets. The more caustic the lime, the deeper the colour of the sulphuret. The pure fixed alkalies, decompose sulphuret of lime, by virtue of their stronger affinity to the sulphur; and any acid whatever decomposes it, by attracting the lime, the sulphur at the same time falling to the bottom in the form of a subtile white powder, formerly called magistery of sulphur.

Pure barites boiled in water with sulphur has but little action upon it.

If a small quantity of magnesia, and an equal quantity of flowers of sulphur, be enclosed in a vessel, perfectly filled up with distilled water, and well stopped, and then exposed to heat by immersion, in boiling water for several hours, a combination will take place; and the water will contain a sulphuret of magnesia.

The fixed alkalies combine very readily with sulphur, either in the moist or dry way, whether they be in a caustic state, or combined with carbonic acid; though more strongly, in the former than the latter case. If a solution of fixed alkali in water, be boiled with half its weight of powdered sulphur, a combination takes place, and a sulphuret is formed. Or if equal parts of dry alkali, and powdered sulphur, be melted in a crucible, and poured out on a flat polished stone, as soon as the fusion is complete, the combination will be of a liver colour, and is the solid sulphuret. If it be made with a caustic alkali, its colour is deeper, and its characteristic properties more intense, than when a mild alkali is used. A solution of the solid sulphuret in water, forms precisely the same substance as the preparation made in the moist way.

All the sulphurets are decomposable by acids, which precipitate the sulphur in a white powder, formerly called milk of sulphur. This, according to Dr. Thomson, is a compound of sulphur and water, which may be rendered yellow like the sublimed sulphur, by expelling its water by means of heat.

The modes of separating the sulphur from the native sulphurets of different metals, have already been given, either under the metals themselves, or the article ORES; but as the subject is of considerable importance, and has been scienti

fically handled in the *Journal des Mines*, by Mr. Gueniveau, engineer of mines, we shall avail ourselves of this opportunity, of introducing his observations.

Among the great number of metallic sulphurets, with which nature presents us, the decomposition of many is of much importance in the arts. The sulphurets of iron, copper, lead, and mercury, and some others, give rise to metallurgical processes, that particularly claim the attention of those who are addicted to the study of chemistry. The nature and properties of these have been well known, since chemistry has made them an object of her labours: but as the facts collected in laboratories have never been caefully compared with those that extensive works furnish, though we are well aware, that this would be the best way of attaining useful results, the theory of the various operations to which sulphurets are subjected has not yet been improved by the progress of that science.

The action of heat on metallic sulphurets requires first to be examined, because it occurs in all the processes employed for their decomposition.

The sulphurets of mercury and arsenic are volatilized in close vessels, when exposed to a temperature a little elevated.

The native sulphuret of iron experiences but a partial decomposition by means of caloric. By distillation in a retort, we cannot extract half the sulphur it contains. In Saxony, the distillation of pyrites in the large way never yields more than 13 or 14 per cent. of their weight of sulphur.

On sulphuretted copper, and pyritous copper, heat produces effects analagous to those observed with iron. The distillation of pyritous copper afforded me but very little sulphur. These two ores, however, may be considered as mixtures of the sulphurets of copper and of iron, and the sulphur separated by heat comes from that of iron almost wholly.

The sulphuret of lead, or galena, is one of those minerals, the treatment of which is most varied. All chemists agree in considering it as a compound of sulphur and lead only, in the proportion of 15 parts sulphur to 85 of lead.

That metallurgical process, the object of which is the desulphuration of metals, is known by the name of roasting. Most authors, who have treated of it, seem to consider caloric as the sole agent in the decomposition; and even those who have remarked the influence of the air, since the establishment of the new chemical theory, have not considered it as essential. The affinities both of sulphur and metallic substances for this principle render it very probable; and it is likewise proved by the chemical examination of the products of all roastings, as well as by the manner in which the process is conducted. In the roasting of sulphurets, instead of seeing the volatilization of the sulphur effected by a moderate and long-continued heat, we find a sulphuret decomposed by the simultaneous action of caloric and air: and the acknowledged necessity of not fusing the ore, instead of arising from the fear of communicating to it by liquefaction a cohesive force capable of resisting the separation of the sulphur, will be ascribed more simply to this circumstance, that such a state will confine the action of the air to a surface that cannot be renewed, and will soon be covered with a metallic oxide.

Roasting of Copper Pyrites.

Pieces of pyritous copper are laid on billets of wood in the most convenient manner for the combustion to continue a long time. The first heat separates part of the sulphur, which is in some degree sublimed, and may be collected; but afterward it becomes the combustible, that serves by burning to continue the operation.

Iron pyrites subjected to the same operation will undergo similar decompositions in the same order.

It remains for us to speak of a furnace, in which both the smelting and roasting of the pyritous copper, to a certain point, are effected at the same time. It is used at Fahlun, in Sweden. This has an interior crucible, which receives the product of a smelting of 24 or 48 hours, and in which a separation, or rather combustion, of the sulphur is effected. A stream of air from the bellows is made to blow on the melted mass with such force, as to drive off the scoriæ, and burn a part of the sulphur that is found on the surface. The iron is thus oxided, and quartz is added to vitrify it in proportion as the roasting goes on. This process is perhaps the only one, in which sulphur and iron are separated in so large a quantity at the same time.

The desulphuration of pyritous copper by roasting appears to be effected, 1st, By the sublimation of a small portion of sulphur, which may either be collected, or burned in the air: 2dly, By the disengagement of sulphurous acid, which is the more abundant in proportion as the process is well managed: 3dly, By the vaporization of a little sulphuric acid, the greater part of which, however, remains united with the copper.

Roasting of Galena.

Galena is very difficult to desulphurate completely by roasting. The affinity of its component parts for oxigen, it is true, render their separation sufficiently speedy; but that of the new compounds, sulphuric acid and oxide of lead, gives rise to a new combination, which retains the sulphur, and thus forms an obstacle to the desulphuration. To this affinity of the oxide of lead for sulphuric acid must be ascribed the facility with which this acid is formed in the roasting of galena.

In roastings in the large way, on hearths prepared for the purpose, the proportion of sulphat of lead is still more considerable, being in the ratio of the temperature, and the facility with which the air pervades the ore.

The reverberatory furnace is employed with great success to roast ores of sulphuretted lead. In some works, indeed, as at Poullaouen, such a complete separation of the sulphur is accomplished in this furnace, that, when the roasting is judged to be finished, nothing more than the addition of charcoal is requisite, to obtain directly a large quantity of metallic lead.

The same furnace is employed with success at Pezey for fusing roasted galena, containing at least one third of its weight of sulphat of lead. Its final result gives no matts; which proves, that it permits the decomposition of the sulphat, and the separation of the sulphur it contains.

Some furnaces have been mentioned, as that of Fahlun, and the Scotch, in which metallic sulphurets undergo a real roasting; but there are others in which this effect is scarcely sensible. Some reflections on their differences in this respect will probably not be out of place here; and they will be the more interesting, as they are intimately connected with our subject, and account for phenomena, which are inexplicable according to the idea generally entertained of roasting.

It is a fact well known in smelting-houses, that the highest furnaces are least favourable to desulphuration, or, in the language of metallurgists, produce the most matts. If an indisputable proof of this were required, we need only say, that at Pezey we have seen roasted lead ores containing a great deal of sulphat of lead, which smelted in the Scotch furnace yielded not matts as the ultimate result, but produced a large quantity in the *fourneau à manche* (a kind of high furnace).

Desulphuration of Mercury.

The sulphuret of mercury is easily decomposed. It is sufficient to present to the sulphur a substance capable of retaining it, and the mercury may be volatilized alone. Thus iron and lime are employed singly or conjointly in the treatment of cinnabarine ores.

Desulphuration of Copper.

Copper pyrites are smelted in some works with lime, either in the *fourneau a manche*, or the reverberatory furnace; but this process is not sufficiently known in detail, to enable us to judge of the efficacy of this agent.

1st Exp. I mixed 10 gram. (155 grs.) of pyritous copper, the composition of which I knew, with 4.3 gram. (66 grs.) of iron filings; put the mixture into a crucible; covered it with charcoal powder; and heated it in a forge fire three quarters of an hour. The proportion of iron was calculated so as to be sufficient for taking up all the sulphur combined with the copper in the ore employed. In the crucible I found a perfectly homogeneous mass, weighing 13.1 gram. (202 grs.) which did not contain the least globule of metallic copper, or any sign of separation between the sulphuret of iron and that of copper.

2d Exp. Another trial was made with 10 gram. (155 grs.) of pyritous copper and 5 gram. (77 grs.) of the same mineral roasted, which is nearly the state of the product when the ore or matts have not been completely desulphurated. The proportion of iron was still insufficient to separate any copper, of which there was abundance in the mixture. I heated it three quarters of an hour, and found, as in the preceding experiment, a homogeneous mass, without any sign of metallic copper, or pure sulphuret of copper: it was a true copper matt.

3d Exp. Equal parts of crude and roasted copper pyrites were mixed, moistened with olive oil, and heated strongly for half an hour in a crucible lined with charcoal. The product was nothing but a powder, that had not undergone any fusion, no doubt owing to the superabundance of iron.

The desulphuration of copper by means of iron will always be very difficult to effect, because a triple compound of sulphur, iron, and copper, is formed, or a combination takes place between the sulphurets of copper and iron, which obstructs the separation of the copper.

Desulphuration of Galena.

Galena is one of those sulphurets in which this decomposition is most readily effected. The fusibility of lead, which

facilitates the union of its particles, as well as the little affinity it has for sulphur, are the causes of the success of the attempts of this kind. Lime and iron are employed in different circumstances for the desulphuration of galena. The use of lime is not very general, and it is impossible to judge of its effects from what is known of the properties of sulphuret of lime. The treatment of galena by malleable or cast iron in small pieces is more in use, and appears very advantageous.

At the School of Mines of Montblanc a great many experiments have been made on the desulphuration of galena by iron, the results of which were of sufficient importance to render the publication of them desirable.

Dr. Watson has shewn, in a paper on lead ore, in the Philosophical Transactions, that no less than seven hundred tons are annually dissipated in the various lead mines of England, for want of a different mode of purifying the ores.

The sulphur that is procured in the roasting of ores, especially those of copper, is apt to contain, besides earthy impurities, a very notable proportion of arsenic, while on the other hand the volcanic sulphur in general, and that of Sicily in particular, is entirely free from this contamination. This is the cause of the universal preference given by the manufacturers of sulphuric acid to Sicilian, over English sulphur; and hence it is a matter of some consequence to be able to ascertain in a compendious and satisfactory manner the purity of any particular sample of this substance. The following method will, we believe, be found to answer every practical purpose. Having rubbed to fine powder in an earthen-ware mortar some of the sulphur to be examined, take 100 grs. and put it into a Florence flask with 5 oz. measures of the *best* oil of turpentine; heat the mixture gently over a lamp, or a pan of charcoal, till it has boiled for about a minute, then pour the clear hot solution into a six or eight-ounce vial, stop it with a cork, and shake it till the liquor has cooled down to the temperature of the hand; it will now be quite turbid with sulphur that has separated from the oil during its cooling, and being run through a glass funnel very lightly plugged with fine tow will pass out clear, leaving the sulphur behind. The oil is now to be again transferred to the sulphur remaining in the flask, and to be a second time boiled, cooled, and filtered as before. By repeating this process four or five times, there will be left only a brownish orange residue, on which the oil will refuse to act any longer. This residue, being laid on a piece of earthen ware, is to be exposed to a heat not higher than that of melting lead, till it ceases to exhale any sulphureous vapours; being then rubbed up with a little moistened charcoal, and pressed into the bowl of a tobacco-pipe or any other convenient vessel, it is to be heated nearly red, upon which a white vapour will arise, and show itself to be arsenic by its peculiar garlic odour. The sulphur precipitated from the oil of turpentine may be entirely freed from this latter by exposure to the air and light for a day or two; it will then be of a beautiful sparkling colour (far superior to that of the common flowers of sulphur) and entirely inodorous. The common brimstone or roll sulphur sometimes contains a full 1-15th of insoluble residue, chiefly orpiment; the best Sicilian sulphur in small rolls, contains hardly more than 3 per cent. of residue, which appears to be little else than earth, as it affords no arsenical odour when heated with charcoal.

To the taste sulphur is perfectly insipid, when broken down, however, by the teeth, it manifests a peculiar indescribable grittiness, which sufficiently distinguishes it from all other bodies. It is inodorous at the common temperature, but when rubbed, a slight fetid smell is sufficiently perceivable; if a roll of sulphur is held for a minute in a moist warm hand, it breaks across with a sharp crackling not unlike the snapping from the discharge of an electrical spark, the hand at the same time contracts a peculiar disagreeable odour, which lasts some minutes. When exposed to a temperature of about 224° Fahr. it melts into a transparent brownish red fluid; by an increase of heat, the fluidity diminishes, and the sulphur begins to sublime in visible vapours; when it somewhat exceeds the temperature of 300° Fahr. its consistence will be viscid and thick like treacle, and the vapour will take fire, the inflammation instantly spreading to the rest of the mass.

Oil of turpentine and the other essential oils dissolve a considerable proportion of sulphur when hot, the greatest part of which they again deposit in crystals, if cooled slowly. The fat oils unite with sulphur by boiling, and acquire a deep yellowish brown colour, and a strong fetid odour; the combination is generally called *balsam of sulphur*. By long repose in a cool place, it deposits small octoedral crystals of sulphur.

For the chemical properties of sulphur, not here enumerated, we refer the reader to elementary treatises on chemistry.

The uses of sulphur are very important. It is employed in medicine; it enters into the composition of sulphuric acid, of gunpowder, and of the common composition for paying the bottoms of ships. Its fumes, when burning, are employed for bleaching silk and wool, and checking the progress of vinous fermentation. Common matches which are in daily use for lighting fires, derive their principal utility from being tipped with sulphur.

SULPHURET, SULPHURETTED HYDROGEN, HYDROSULPHURETS, &c.--The various combinations of sulphur with alkaline, earthy, and metallic bases, of sulphur with hydrogen, and the latter compound with the several bases in different proportions of sulphuration, are so intimately connected, that we give the whole under one article.

The several combinations which belong to this subject, are,

1. *Sulphuretted Hydrogen,* composed of hydrogen holding sulphur in solution, and when uncombined with a base assuming the gasseous form.

2. The *Hydrosulphurets,* or combinations of sulphuretted hydrogen with the several alkaline, earthy, and metallic bases, in which its action strongly resembles that of an acid.

3. The *Sulphurets,* or combinations of sulphur with the alkalies, earths, and metals.

4. *Supersulphuretted Hydrogen,* or sulphuretted hydrogen, with a considerable, but, in general, an uniform excess of sulphur.

5. *Sulphuretted Hydro-sulphurets,* or combinations of sulphur, sulphuretted hydrogen, and the alkaline or earthy bases.

SULPHURIC ACID, *Vitriolic Acid, Oil of Vitriol.*—This acid, perhaps the most important of any for its extensive use, is said to have been found by Baldassari in a concrete state, lining a grotto in mount St. Amiato in Tuscany; it also occurs in the crevices of volcanic mountains, and dissolved in a few mineral waters. It is not, however, from any of these sources that the sulphuric acid of commerce is obtained, the whole of this being procured either from the distillation of sulphat of iron, or from the combustion of sulphur.

Sulphat of iron (or green vitriol) as we have elsewhere shown, consists of sulphuric acid, water, and oxyd of iron; by proper methods the acid may be separated from the other ingredients of the salt; and this continued to be the only origin of sulphuric acid in the great way, till the discovery, by the manufacturing English chemists, of the art of preparing it by the combustion of sulphur. As this latter discovery has not, however, as yet entirely superseded the former, we shall give an account of both, beginning with the most ancient.

Sulphuric acid is thus prepared at Bleyl in Bohemia. A long horizontal furnace or gallery of brick-work is constructed capable of receiving a number of retorts; the retorts themselves are pear-shaped vessels, with a slightly curved neck, by which they fit into earthen receivers nearly of the form of common retorts. The whole apparatus being prepared, each retort is charged with 3 lbs. of sulphat of iron, previously calcined at a full red heat, and the fire is lighted. The first effect of the heat is to drive off the moisture absorbed by the vitriol in the interval between its calcination and distillation; this phlegm being only very slightly acidulous is allowed to escape, and when it ceases to come over, the receiver with a little water in it, is luted on to the retort; the fire is now raised and kept up brisk for 32 hours, during which time the acid rises in the form of dense white vapours, which fill the receiver, and are there absorbed by the water. These vapours being at a high temperature soon render the receiver very hot; hence the workmen judge of the termination of the process by the receiver becoming cool in consequence of the vapour ceasing to rise. The red oxyd of iron or colcothar, is now taken out of the retort, and its place is supplied with a fresh charge of calcined vitriol; the distillation then takes place as already described, except that the former produce of acid is not emptied out of the receiver, and therefore there is no occasion to add any water. If the retort is well made and carefully luted all over, it will last for three successive distillations, and the quantity of acid obtained is nearly equal to half the weight of the calcined sulphat.

If the acid be examined at different periods of the distillation, it will be found to be more and more dense, according to the violence of the fire required for its extrication; the latter portion, if received in a separate vessel, will generally congeal upon cooling, hence it is called *glacial sulphuric acid;* this property, however, is not entirely owing to its density, as we shall presently show.

The sulphats of copper and zinc have occasionally been employed, instead of the sulphat of iron, but with a manifest disadvantage, both because they are dearer

than the latter salt, and because they require a higher and longer continued heat to drive off the whole of the acid.

The following is the usual method of manufacturing sulphuric acid from the combustion of sulphur. A chamber is constructed of frame work, and lined with strong sheet lead; the only aperture is a small door, made to shut very close, the bottom of which is a little higher than the floor of the chamber. Water is poured into this chamber till it rises to the height of an inch or two upon the floor, and a stand is introduced on which is placed an earthen pot, containing a few pounds of sulphur and nitre, in the proportion of from eight to ten of the former to one of the latter; this mixture is set fire to, by means of a red hot iron, and the door is immediately closed; at the expiration of about six hours a second charge of sulphur and nitre is introduced, which after a similar interval is replaced by a third, and so on, without intermission, for a fortnight or three weeks. At the end of this period, the water in the chamber is sufficiently acidulated; it is accordingly transferred to a leaden boiler, where the greater part of the water is evaporated; in proportion, however, as the acid becomes more concentrated, it is more disposed to corrode and dissolve the lead of the boiler; therefore, before this degree of concentration takes place, the liquor is transferred into large green glass retorts, where a degree of heat is applied sufficient to drive off almost the whole of the water. As the acid becomes stronger, it also becomes clearer and less coloured in consequence of a portion of acid reacting on the impurities with which it is tinged, and thus destroying them. When the acid is thus brought to the required density and clearness, it is poured out of the retorts into large globular glass bottles, surrounded with wicker work stuffed with straw (called *carboys*) and is then brought into the market, under the name of *Oil of Vitriol*.

The sulphuric acid obtained from the distillation of green vitriol exists ready formed in the salt, its extrication is a perfectly simple process, and the only impurities that it can possibly contain are sulphurous acid, and a very minute portion of oxyd of iron, and of the earth of the retort. When loaded with sulphurous acid it has a suffocating odour, and when exposed to the air gives out a white vapour like strong muriatic acid: it used formerly to be sold in this state by the name of *fuming oil of vitriol*, and was further distinguished by its property of congealing into a soft ice, at a very moderate degree of cold. By dilution with a little water, and subsequent boiling for a few minutes in a glass vessel, the sulphurous acid is driven off, and the residual fluid is common sulphuric acid in a state of very considerable purity.

It might be imagined *a priori*, that sulphur would be convertible by simple combustion into sulphuric acid; this, however, is by no means the case. In the first rude attempts to obtain sulphuric acid by this process, the method employed was the following: a large shallow bason was half filled with hot water, and an earthen crucible, or other convenient vessel, filled with melted and ignited sulphur, was fixed by means of a stand in the middle of the bason, and just above the surface of the water; a large bell glass was then whelmed over the pot of sulphur, and brought nearly, though not quite in contact with the water; in this situation the vapour arising from the combustion of the sulphur, rose into the bell glass, where it mixed with the steam of the hot water, and condensing, trickled in drops down the sides of the glass into the bason. But though by this process a certain quantity of sulphuric acid was obtained, yet so large a portion of the sulphur escaped in incondensible suffocating sulphurous acid gas, as to render it both a very offensive and uneconomical mode of proceeding. Nor does the want of success in these experiments appear to have arisen from any imperfection of the apparatus, or want of care in the manipulation, for they have since been repeated by various manufacturers on a great scale, but with the same result as at first. Chaptal appears to have bestowed particular care on this subject; we shall, therefore, state the results of his experiments. The apparatus employed by this able chemist, was a leaden chamber, with a stove constructed on the outside, and communicating by means of a flue with the chamber. In this stove the sulphur was melted, and a blast of air being directed on its surface, combustion took place, and the products of this combination passed into the leaden chamber, and were thus brought in contact with the water which it contained. When the current of air passed very rapidly over the sulphur, only a very small quantity of this latter suffered combustion, the greater part being simply involved in the air in a minutely divided state, and deposited within the chamber in the form of flowers of sulphur. By moderating the rapidity of the current of air, the combination of the sulphur with oxygen is more complete, a large quantity of sulphurous acid is produced, and part of the sulphur

is found covering the surface of the water in form of a thin elastic skin. If the current of air is rendered still slower, so as but just to keep up the combustion, the whole of the sulphur is acidified, but so large a portion of it is, in the state of incondensible gas, that the product of true sulphuric acid is altogether insignificant. In one of M. Chaptal's experiments he burnt in the course of seven days 1135 lbs. of sulphur, at the end of which time so prodigious a quantity of suffocating gas poured out from the chamber as to render it necessary to stop the process; in three or four days after, the door of the chamber was opened, and after the gas had escaped, it was found that the water on the floor of the chamber was covered with a flexible skin of sulphur, and was scarcely at all acidulous to the taste.

In a second experiment the combustion was much slower, 2900 lbs being burnt in the space of thirty-three days; during the process much sulphurous acid gas escaped, and on the chamber being opened there was no appearance of sublimed sulphur or of film upon the water, so that the whole of the sulphur had undergone combustion, but the product of condensible acid was so small that the water was only slightly acidulous, and scarcely effervesced with carbonated alkali. Hence it appears, that though atmospheric air will effect the combustion of sulphur, yet the product is little else than incondensible sulphurous acid.

Several other methods have been tried to supersede the necessity of employing nitre, but with little or no success. Water contains a large proportion of oxygen in its composition, and is readily decomposable at a moderate heat by a variety of substances, attempts have been accordingly made to employ it for the oxygenation of sulphur If to some of this latter, when melted and ignited, there be added water drop by drop, at short intervals, the flame of the sulphur will be enlarged, its colour will become of a yellowish tinge, and a dense white vapour will arise from it; but this latter, when condensed, appears to be only very slightly acidulated water, highly charged with minutely divided sulphur. A more likely method of producing sulphuric acid was by mixing with the sulphur a portion of black oxyd of manganese, capable of furnishing a quantity of oxygen equal to that contained in the proportion of nitre usually employed; but though this mixture has been treated in various ways, it does not appear capable of furnishing a greater quantity of sulphuric acid, than when sulphur is simply burnt in atmospheric air. Even oxygen gas itself, when distributed by means of a pipe over the surface of heated sulphur; is by no means comparable in efficacy to nitre: the rapidity of the combustion is indeed very rapidly increased, but the product is almost entirely sulphurous acid gas.

When the method of producing sulphuric acid by the combustion of sulphur and nitre was first discovered, the apparatus employed was a series of very large glass balloons, at the bottom of each of which was a little water to condense the vapour; only a small quantity of the mixture could be burnt at once, and constant superintendance was necessary to supply the balloons with fresh charges of the materials. In order to save much of this manual labour, and the heavy loss arising from the frequent fracture of the vessels, leaden chambers were made use of, which besides requiring less attendance, and being upon the whole cheaper, rendered it easier for the manufacturer to extend his establishment to any required magnitude. These chambers are of various construction; the most simple and in most general use, are furnished only with two apertures, namely, a small door, by which the water and the sulphur and the nitre are introduced, and a leaden pipe with a stop cock, by which the water, when acidulated, is drawn off; other chambers have besides a few small apertures for the introduction of atmospheric air during the combustion, and a steam pipe connected with a boiler, it being found that if the water is introduced in the state of steam, a much more rapid condensation of the acid ensues than in the usual way of proceeding. In some of the best contrived chambers the combustion of the nitre and sulphur is effected in a separate stove, and the acid vapour thus produced is poured by means of a pipe into the condensing chamber.

There is a good deal of difference among the manufacturers as to the proportion of nitre employed; by some it is made equal to one-fifth of the sulphur, while by others it is not allowed to exceed one-tenth. This, however, appears to be satisfactorily established, that within the above limits the greater the proportion is of nitre, the more easily condensible will the acid vapour be, and the less sulphur will be lost in the form of sulphurous acid gas. If the nitre exceeds one-fifth of the sulphur, the combustion will be so rapid as to drive into the chamber a considerable proportion of sulphur unaltered. The acid vapour is of a dense opake white colour, and, according to Chaptal, is considerably luminous: when as much of it is

condensed as is capable of being so in the usual process, the residue becomes quite transparent, and is for the most part a mixture of sulphurous acid gas and nitrous gas; it has a peculiar and very pungent suffocating odour, and upon opening the door of the chamber, it presently acquires a faint orange red colour, by combining with the oxygen of the air, and thus forming nitrous acid vapour; this, as soon as formed, re-acts on the leaden lining of the chamber, corroding it deeply, and is the principal cause of the sulphat of lead, which common sulphuric acid always contains, and often in considerable abundance. It would conduce much to the purity of sulpharic acid, and might probably be found even to be an economical plan, to line the chamber with glass instead of sheet lead; the general appearance of the chamber would then resemble a green-house, and all the wood work should be faced internally with glass; a composition of wax, mastich and fine sand, would form a strong cement for the glass, and little liable to be acted on by acid vapours, more especially if the interstices filled up with it were dusted with powdered glass or very fine sand, while the cement was yet warm and adhesive. Such a chamber would have the additional advantage of allowing the operator to see what was passing within, without the necessity of opening the door.

With regard to the strength of the acid when withdrawn from the condensing chamber, we are informed by Chaptal, that in his manufactory it used to mark between 40° and 50° on Beaumé's areometer; it was then evaporated in leaden boilers, till it arrived at 60° of Beaumé, and was lastly condensed in glass retorts till it was equal to 66°, and was then at the common density of the oil of vitriol of commerce. We are told by the same author, that one part of sulphur affords nearly two parts of sulphuric acid at the above density: this, however, appears to be a mistake. We should imagine that in the common manufactories the loss by sulphurous acid gas would nearly counterbalance the increase from the addition of oxygen and water; indeed it is expressly stated by some authors that 100 pounds of sulphur produce by combustion an equal weight of sulphuric acid.

It has been already mentioned that the common English sulphur (and probably all that which is obtained during the roasting of copper ore) is unfit for the preparation of sulphuric acid, on account of a yellowish-brown colour that it gives to this fluid, and which it is extremely difficult to get rid of. For this reason the refined Sicilian sulphur is the only kind that is employed in this manufacture, at least in Britain. But though by the due selection of sulphur one source of impurity is avoided, yet there are others which, according to the usual mode of preparing this acid, it is impossible to escape. The watery acid, as it runs from the leaden chamber, is necessarily mixed with sulphat of lead, with a small quantity of nitrous acid, and holds suspended in a minutely divided state, a portion of sulphur, from which it acquires a yellowish colour: during the evaporation in the leaden boilers, probably a little more sulphat of lead is taken up. The high heat required for the final concentration of the acid in the glass retorts, by causing the nitrous and part of the sulphuric acid to re-act on the diffused sulphur and other inflammable impurities, takes away, for the most part, the colour from the fluid, and drives off the whole of the nitrous gas and sulphurous acid, together with a portion of water: thus the only impurity that finally remains in the sulphuric acid is sulphat of lead. But it not unfrequently happens that the acid, during concentration, loses its colour very slowly, to expedite which it is usual to add a little nitre, the acid of which being set at liberty, acts rapidly on the colouring matter and destroys it, being itself finally driven off in the state of nitrous gas. The alkaline base of the nitre, however, remains dissolved and combined with the sulphuric acid, so that besides sulphat of lead, it is further contaminated by sulphat of potash; and if the nitre is added somewhat in excess, and only a little while before the concentration is finished, it is very probable that a portion of nitrous acid will still remain. Nor is it of trifling moment that the whole of the nitrous acid should be expelled; for if the dyer or calico printer employs an impure acid of this description in making Saxon blue (sulphat of indigo) he will find to his cost that he has got a green instead of a blue pigment. From the occasional occurrence of the above and other similar disappointments, it is that the dyers on the continent, when they can procure either the sulphuric or the genuine *vitriolic* acid, always prefer the latter, notwithstanding the great superiority of its price.

Common sulphuric acid may be freed from the sulphats of lead and potash which it generally contains, by distillation; this however, though apparently a very simple process, is rather a nice matter to manage, according to the usual method. Sulphuric acid is not capable of being distilled at less than a red heat;

when, therefore, the dense hot vapour first comes in contact with the necks of the retort and receiver, it is apt to break them, unless the precaution has been taken of thoroughly heating them by means of a pan of charcoal placed beneath, a minute or two before the distillation commences. All this risk, however, may be avoided (and in some laboratories it actually is so) by connecting the glass body, in which the acid is boiled, with the receiver, by means of a tube of platina: boiling sulphuric acid has not the least action on this metal, and the vapour in its passage through becomes so far cooled and condensed, that it flows into the receiver in drops.

The manufacture of vitriolic acid is thus given by Thomas Cooper, esq. Professor of Chemistry in Dickinson college, Carlisle; extracted from the Archives of Useful Knowledge.

Set up the frame of a room, 20 feet by 30 feet, and 18 feet high. Of this room, the sides and the ceiling should be lined with milled lead, about 6 lb. to the foot. The bottom should be of lead 8 lb. to the foot, with a plug to let off the liquor close. Two feet six inches from the bottom, on the 20 foot side, should be, at equal distances from the sides and from each other, two trap doors, eighteen inches square, that move up and down in a groove by means of a pulley. Opposite to each of these trap doors should be an iron frame about a foot wide in the clear, and set on leaden feet, or lumps of lead, four inches at least from the bottom of the room. Each of these frames are destined to hold three or four stone ware, or porcelain pans, 15 inches diameter, and 4 inches deep, which are to be half filled with brimstone and saltpetre, ground together and sifted, in the proportion of 8-9ths of brimstone and 1-9th of saltpetre. Fix the pans on the frames or tressels, light the mixture by a red-hot iron, shut the trap doors, and let them burn. The nitre supplies oxygen to the sulphur, which is converted into volatile vitriolic acid. If water could be admitted on the top and outside of the room, the condensation would be assisted. Much volatile nitrous acid is also disengaged by the action of the new-formed vitriolic acid on the saltpetre, which may occasionally be let out by a trap door on pullies, towards the top of the further side of the room. When the pans of the mixture are extinguished, leave the room close for an hour before you take them out; then empty, fill, and light them again. After three burnings, a jet of cold water may be thrown in by a hand pump, so as to extend in a scattered rain-like stream through the room. Then open the trap doors, and admit a current of air. Do not throw in too much cold water, as it will require more fuel. Draw off the contents at the bottom, and evaporate for two hours by a strong fire, in leaden retorts, or pans; then finish in large glass retorts in a sand bath. In England, the glass retorts hold 90 lbs. of oil of vitriol, when concentrated, which is one half too much, for unless the men are very careful, they are apt to break them. In Scotland they concentrate entirely in lead. Oil of vitriol should weigh 29½ oz. to the wine pint, measured and weighed in a Florence flask, &c. The residue of the pans may be ground with the brimstone and burnt again. The pans would be better if they ran upon small inch wheels in a groove in the frame, and were drawn out by a crooked iron.

Sulphuric acid, when pure, is perfectly transparent, and colourless; but the common oil of vitriol of the shops has almost always a very pale hair brown tinge, probably arising from the carbonization of a little of the cement with which the bottles in which it is kept are closed. In its general appearance and consistence, when shaken, it is not unlike oil, whence it derived its commercial name, *oil* of vitriol. It is entirely inodorous: to the touch it is at first smooth and unctuous, but it presently after excites a violently burning sensation, and corrodes the skin with great rapidity; even when largely diluted with water, it is acerb and intensely sour, and sets the teeth on edge. It changes most vegetable blues to red, and exhibits the other generic characters of acids in an eminent degree.

The sulphuric acid is considerably denser than any other acid or transparent fluid, and in general its affinities are stronger. It strongly attracts water, which it takes from the atmosphere very rapidly, and in larger quantities, if suffered to remain in an open vessel, imbibing one third of its weight in twenty-four hours, and more than six times its weight in a twelvemonth. If four parts by weight be mixed with one of water at 50°, they produce an instantaneous heat of 300° Fahrenheit; and four parts raise one of ice to 212°: on the contrary four parts of ice, mixed with one of acid, sink the thermometer to 4° below 0. When pure it is colourless, and emits no fumes. If it be heated, it becomes more and more concentrated by the loss of a portion of water, which rises before the acid itself. Its specific gravity ought to be 1.85, at which it is taken by the London college; but it may be brought, by evaporation in a sand

heat, to 2 or upward. At this strength it requires a great degree of cold to freeze it; and if diluted with half a part or more of water, unless the dilution be carried very far, it becomes more and more difficult to congeal; yet at the specific gravity of 1.78, or a few hundredths above or below this, it may be frozen by surrounding it with melting snow. Its congelation forms regular prismatic crystals with six sides. Its boiling point, according to Bergman, is 540°, according to Dalton 590°.

Attempts have been made to ascertain the proportions of the constituent principles in this acid, but chemists have differed considerably on this head. Tromsdorf carries the sulphur as high as 70 per cent. and Berthollet even to 75, while Klaproth, Richter, and Bucholz, make it little more than 42. Lately Mr. Chenevix has made some very careful experiments on the subject, which give 51.5 for the proportion of sulphur, and their accuracy is strengthened by others made by Doctor Thomson of Edinburgh; and it is probable the other chemists may have erred from mistaken calculuations of the component parts of the salts employed in the analysis.

The sulphuric acid is of very extensive use in the art of chemistry, as well as in metallurgy, bleaching, and some of the processes for dyeing: in medicine it is given as a tonic, stimulant, and lithontriptic, and sometimes used externally as a caustic.

The combinations of this acid with the various bases are called sulphats, and most of them have long been know by various names. For further particulars consult the different authors on chemistry.

SULPHUREOUS ACID. This acid, as used in the arts, is employed particularly in the bleaching of straw, silk, flannels, &c. which is used, however, only in a certain manner. See BLEACHING. The acid, in a liquid state, or the sulphureous acid gas combined with water, however, is seldom employed; but the acid in the aeriform state, is the most general mode of applying it. The goods are moistened, and exposed, in a confused situation, to the gas produced by the slow combustion of sulphur.

As the acid obtained by burning sulphur in this way, is commonly mixed with more or less sulphuric acid, when sulphurous acid is wanted,it is commonly made by abstracting part of the oxygen, from sulphuric acid, by means of some combustible substance. Mercury or tin is usually preferred. For the purposes of manufactures, however, chopped straw or saw-dust, may be employed. If one part of mercury, and two of concentrated sulphuric acid be put into a glass retort with a long neck, and heat applied till an effervescence is produced, the sulphurous acid will arise in the form of gas, and may be collected over quicksilver, or received into water, which at the temperature of sixty-one degrees, will absorb thirty-three times its bulk, or nearly an eleventh of its weight.

Water thus saturated, is intensely acid to the taste, and has the smell of sulphur burning slowly. It destroys most vegetable colours, but the blues are reddened by it, previous to their being discharged. A pleasing instance of its effect on colours may be exhibitted, by holding a red rose over the fumes of burning sulphur.

Sulphuring is generally performed in the large way, in an arched or very close chamber, constructed in such a manner, that the articles to be exposed to the action of the sulphur can be suspended on poles. The chamber being filled, a certain quantity of sulphur, is put in a state of combustion in flat dishes, having a large surface, with very little depth; the entrance is speedily shut, and all the interstices around the door are carefully stopped, to prevent the access of the atmospheric air. The acid generated by the combustion of the sulphur, penetrates the stuffs, attacks the colouring matter, destroys it, and effects the bleaching. The stuffs are left in the stoves sometime after the deflagration has ceased.

This time varies from 6 to 24 hours. They are then taken out, and made to pass through a slight washing with soap, to remove the roughness they have acquired by the action of the acid, and to give them the necessary softness.

This process is imperfect. At first, the acid of the sulphur acts only on the surfaces, and does not penetrate. This aerial immersion is not sufficient; the gas cannot introduce itself, to a sufficient depth into the stuffs, and the superfices only are whitened.

A superior method has been lately invented, which is by making use of the sulphureous acid, as before stated.

The pieces are rolled upon the reels, and are drawn through the sulphureous acid, or water impregnated with the gas, by turning them, until it is observed that the whiteness is sufficiently bright. They are then taken out, and are left to drain on a bench covered with cloth, lest they should be stained in consequence of the decomposition of the wood by the sulphureous acid; they are next washed in river

water, and Spanish white is employed, if it should be judged necessary. This operation is performed by passing the pieces through a tub of clear water, in which about eight pounds of Spanish white have been dissolved. To obtain a fine whiteness, the stuffs, in general, are twice sulphured. According to this process, one immersion and reeling two or three hours, is sufficient.

SUMAC OR SHUMAC. Besides the remarks under the head of shumac, we thought it better to add a few observations on some of the chemical properties of this plant, more especially on its use in dyeing

Common sumach (rhus coriaria) is a shrub that grows naturally in Syria, Palestine, Spain, Portugal, and America; its shoots are cut down every year quite to the root; and after being dried, they are reduced to powder by a mill, and thus prepared for the purposes of dyeing and tanning. The sumach cultivated in the neigbourhood of Montpelier, is called rédoul or roudou.

The infusion of sumach, which is of a greenish fawn colour,soon becomes brown by exposure to the air: a solution of potash, produces but little change on it, while recent; acids brighten its colour, and turn it yellow; solution of alum renders it turbid, and produces in it a small quantity of yellow precipitate; the liquor remains yellow.

Mr. Proust has shown, that sumach contains abundance of sulphat of lime; and it is probably owing to this, that its infusion gives dense precipitates, with the caustic alkalies.

Mr. Hatchett found, that an ounce contains about seventy-eight or seventy-nine grains of tannin.

Sumach acts on a solution of silver just as galls do: it reduces the silver to its metallic state, and the reduction is favoured by the action of light.

Sumach alone, gives a fawn colour inclining to green; but cotton stuffs, which have been impregnated with printer's mordant, that is, acetate of alumine, take a pretty good and very durable yellow. An inconvenience is experienced in employing sumach in this way, which arises from the fixed nature of its colour; the ground of the stuff does not lose its colour by exposure on the grass, so that it becomes necessary to impregnate all the stuff with different mordants, to vary the colours, without leaving any part of it white.

SUN-FLOWER-OIL. See Oil.

SWEDISH STONE PAPER. The chief use of this paper is to cover houses; it is therefore made of such materials as will stand the weather. As paper is the basis, it is evident that it must be impregnated with such substances as will have the effect, of making it impervious to water.

The Red Stone Paper.

Is made of martial ball, vegetable matter, animal glue, and linseed oil.

The White and Yellow Stone Paper,

Has the same materials, except the ball, in the place of which chalk, ochre, &c. are used. The mode of preparation consists in forming the rags, or in their place, paper, into a pulp by boiling with water; then mixed with dissolved glue, and made into a paste, with the above earthy or ochrous matters, and some copperas, and the whole beat in a mortar with linseed oil. The mass being prepared in this manner, is to be spread out with a spatula above a sheet of coarse paper, placed on a board furnished with a rim or border. The whole being inverted, the board with the rim is to be taken off, and the compressed mass is to be laid upon another board, sprinkled with sand, and left to dry, after taking the sheet of paper from its other side. Squares made in this manner, dry without cracking.

We shall now enumerate some experiments made by a chemist, in his investigations into the composition of this paper, viz.

"Experiment. I. I mixed an ounce and a half of the dry pulp from the mill, with two ounces of common glue, and, having added red bole and ochre, of each two ounces, obtained a smooth plate.

"II. To two ounces of pulp I added four ounces of red bole pulverized, and half an ounce of chalk, with an ounce and a half of glue. The plate thus produced was full of wrinkles and chinks, but tolerably hard.

"III. An ounce and an half of pulp, with four ounces of bole, and two of sulphat of iron, produced a plate equally hard, but uneven.

"IV. An ounce of pulp procured from old paper, and bookbinders' shavings, mixed, with half an ounce of glue, one ounce of powdered chalk, two of bole, and one ounce of linseed oil, produced two thin plates smooth and hard.

"V. Two ounces of pulp from the mill, with half an ounce of glue, six ounces of red bole, and two of chalk, to which were added two ounces of sulphat of iron, and the same quantity of linseed oil, afforded plates that were smooth, but not strong.

"VI. An ounce and a half of pulp, with an ounce of glue, and four ounces

of white bole, produced a plate smooth, beautiful and hard.

"VII. An ounce and a half of pulp, mixed with two ounces of glue, two ounces of white bole, and as much chalk, yielded a smooth plate as hard as bone.

"VIII. An ounce of pulp, one ounce of glue, three ounces of white bole, and an ounce of linseed oil, produced a plate sufficiently perfect and elastic.

"IX. A plate which I formed of one ounce of pulp, with half an ounce of glue, three ounces of white bole, one ounce of chalk, and one ounce and a half of linseed oil, was superior to that mentioned in the preceding experiment. This substance retains figures impressed upon it, and tinged with half a drachm of Prussian blue, assumed a blueish-green colour.

"X. An ounce and a half of pulp, with one ounce of glue, and four ounces of chalk, afforded a plate exceedingly spongy.

"XI. An ounce and a half of the same pulp, one ounce of sulphat of iron, and four ounces of white bole, without glue, produced a plate yellowish and spongy.

"XII. An ounce and a half of pulp, four ounces of white bole, with an ounce of sulphat of iron, and the same quantity of glue, produced a yellowish plate a little more solid.

"The cement which the Swedes recommend, for filling up the interstices between the squares, is composed of linseed oil varnish, white lead and chalk, mixed together in such a manner, as to approach to a fluid state, that it may more easily insinuate itself into the fissures

"As the chief use of this invention is to cover and incrust houses, I was desirous of trying my production, by exposing it to the effects of the weather. I therefore nailed fragments of the Swedish stone paper, and of that made by myself, to a small board; and having daubed over the joinings with cement, I exposed them in the month of August, on the top of my house, and in the beginning of April the next year, I found they had undergone no change"

SWINE. See Animals Domestic.

SYMPATHETIC INKS. See Inks.

SYPHON. See Hydrostatics.

SYRUP. This is a preparation of sugar, made by dissolving it in water, and evaporating it, till it acquires the consistence of soft honey. Simple syrup is a solution of sugar boiled in this manner; molasses or treacle, is an inferior and at the same time an impure syrup. In the shops of the confectioners and apothecaries, we have various medicated and other syrups, which are made by adding other substances to the simple syrup, or by the boiling of sugar with sundry fluids. Thus, syrup of vinegar, lemon, &c. is prepared by boiling sugar in vinegar, or lime or lemon juice, till it acquires the due consistence.

T.

TABLE, *Mill-Wrights'*. See Mechanics.

TABLE BEER. See Beer.

TACKLE. See Mechanics.

TALC. Magnesia .44, silex .50, and alumine .06, according to the analysis of Mr. Hœpfner, constitute Venetian talc.

Its colour is white, gray, yellowish, or greenish; it is soft and soapy to the touch, and in thin pieces semitransparent; it is composed of very thin plates, disposed in a laminar or filamentous form, much tenderer and more brittle than those of mica, but like this it has a metallic lustre; its hardness is so inconsiderable, that it may be scratched with the nail; and its specific gravity is 2.729.

It does not effervesce with acids; and is soluble therein with difficulty, by particular management, and only in part.

In fire it becomes more brittle and whiter, but is infusible per se by the blowpipe, and scarcely fusible by fixed alkali, but more completely and with little effervescence by borax or microcosmic salt.

Muscovy talc consists of broad, elastic, flexible, transparent leaves; and differs externally from mica only in being softer and more soapy to the touch. Its analysis by Vauquelin gave silex .62, magnesia .27, oxide of iron .035, alumine .015, water .06.

It abounds in the hills of Bahar, and other parts of India, where its market price, split into sheets about 2 lines thick, is at the rate of 24 lbs. avoirdupois for a rupee (2s. 6d.) The natives, as well as the Chinese, make very splendid lanterns, shades, and ornaments of it, tinged of various colours. They likewise use it in medicine, considering it when calcined, a

specific in obstinate coughs and consumptions. Powdered, it makes a silver sand for writing.

This mineral is employed in preparing compositions for earthen vessels: on account of its smoothness, brightness, and unctuous quality, it has been celebrated as a cosmetic; and various unsuccessful experiments have been made, with a view to extract from it oils, salts, and other supposed ingredients....When combined with alkaline salts, it is fusible in a strong heat, and forms a transparent, handsome, greenish-yellow glass: if equal portions of talc and of chalk be melted together with one-fourth part of borax, the mixture will produce a fine pellucid greenish glass, which is of considerable lustre and hardness.

TALLOW.—We do not know of any experiments, which ascertain a chemical difference between this concrete animal fat, which is chiefly taken from the intestines of animals, and other fat oils of the same nature. The most valuable property of tallow is, the considerable heat it requires to fuse it, which is commonly distinguished by the term hardness. The quantity of soot and fetid exhalation emitted from the various kinds of tallow candles brought to market, also forms a distinguishing characteristic in the use of this article, and is accompanied with notable variations in the quantities of light afforded by each.

It is an object of no small importance to purify or improve tallow. The tallow-chandlers clear it of fibrous matter and other gross impurities by careful melting, straining, and the like mechanical management. It is said also, that they improve its whiteness by the addition of alum, the efficacy of which we are much disposed to doubt. It is thought, too, that long keeping, and the action of the external air, improve its hardness; but these slow operations are ill calculated for a manufactory, in which the greatest part of the capital is vested in the raw material, and very little in the manufacturing process: and if they increase the hardness of the tallow, they injure the colour, and candles kept too long do not burn so well.

The melting of tallow is done by chopping the fat as it is taken from oxen and sheep, and then boiling it for some time in a large copper, and when the tallow is extracted by the process of fire, the remainder is sujected to the operation of a strong iron press, and the cake that is left after the tallow is expressed from it is called a greave.

The oxigenized muriatic acid produces a state in tallow, which is somewhat nearer to that of wax than before, and a thin stratum of tallow exposed upon an extended surface of water becomes likewise harder; but the indications these processes might afford to the manufacturer, have not yet been applied to any extended purposes of utility.

TALLOW-CHANDLERY, or, more properly, candle-making, is a profession which is partly chemical and partly mechanical. After preparing the wick, which is done agreeably to a rule established, the next operation is the covering of it with tallow.

The tallow is first melted in a large copper, and after it is well skimmed and refined, it is brought into a vessel called a *mould*, in which the cottons are dipped. The workman holds three of these broaches between his fingers, and immerses the cottons into the mould: they are then hung on a frame, for the purpose, till they become cold and hard; during which others are dipped When cold, they are dipped a second and a third time, and so on till the candles are of the proper size.

During the operation, the tallow is stirred from time to time, and the mould supplied with fresh tallow, which is kept to the proper heat by means of a fire under it.

Such was the laborious method univesally adopted in making common candles, till within these fifteen or twenty years, when an invention was introduced, and may be thus described:—In a beam three pulleys are let in; round these, proper sized ropes run, and are fixed to a machine on which six broaches are placed. In the scale are weights sufficient to draw up the broaches: these are increased as the candles become larger and heavier. The workman, by means of this very simple and excellent contrivance, has only to guide the candles, and not to support the weight of them between his fingers.

Mould candles, as the name expresses, are cast in a mould. The frame is of wood, and the several moulds are hollow metal cylinders, generally made of pewter, of the diameter and length of the candle wanted, &c. *Rush-lights* have a split rush for the wick.

Professor Medicus has given the following observations on the method of preparing tallow candles with wooden wicks.

For several years past tallow candles with wooden wicks have been prepared, in large quantities, by the candle-makers at Munich, and much used in that neighbourhood. I have burnt them during the

whole winter, and never wish to use any other kind, as they are attended with several advantages which common tallow candles do not possess. They afford about the same quantity of light as a wax candle; burn also with great steadiness and uniformity, and never crackle or run. The candle-makers here keep the method of preparing these candles as secret as they can; but I shall communicate to the public what I have been able to learn respecting the process.

The only difference between these candles and the common tallow candles, is, that the ground-work of the wick consists of a very thin slip of wood, bound round to a considerable thickness with very fine unspun cotton; but in such a manner that the size of the wick does not much exceed that of the wick of a common candle. The cotton is sometimes wound round the wick by the hand; but in general it is done by means of a reel, which I have not yet been able to see. The thin slips of wood are furnished to the candle-makers by the country people, and, if we may judge from their appearance, are cut into the proper form by means of a knife, without the application of any machine. They are for the most part somewhat square, and not completely rounded. The candle-makers often prepare these slips of wood also themselves, when they have none ready by them, and for that purpose use pine, willow, and other kinds of wood, though they commonly employ fir. For making these candles it is necessary to have the purest tallow: a pound will be sufficient to make six or seven, which cost twenty-five kreutzers. The price of common moulded candles with cotton wicks is twenty-two kreutzers; but as the former burn much longer, they are on the whole cheaper.

Another method of making the wicks is as follows: Take shoots of the pine tree a year old, scrape off the bark, and when they are become perfectly dry scrape them again all round till they are reduced to the size of a small straw. When the above wood cannot be procured, well dried common fir twigs of a year old, and of the same strength, may be prepared in the like manner. These rods are then to be rubbed over with wax or tallow, till they are covered with a thin coating of either of these substances; after which they must be rolled on a smooth table in very fine carded cotton, drawn out to about the length of the rod or candle-mould. Care, however, must be taken that by this rolling no inequalities may arise on the rod, and that the cotton may be every where of equal thickness, though at the upper part a little more of it, may be applied. After this preparation, the wick will have acquired the size of the barrel of a small quill; and the more accurately the size of the wick is proportioned to that of the candle mould, the candles will burn so much the better, clearer, and longer, as will soon be found by a little experience: these wicks are then to be placed very exactly in the middle of the mould, and retained in that position, and good tallow, fresh if possible, previously melted with a little water, must be poured round them; but even old and rancid tallow will not run, if the wicks be properly made.

These candles, besides burning longer than the common ones, have also this advantage, that they do not flare, and that they are less prejudicial to the eyes of those who are accustomed to read or write at night. It is, however, to be observed, that a pair of sharp scissors must be employed for snuffing them, and that in performing that operation care must be taken not to break or derange the wick.

The following observations on the theory of combustion, may be noticed in this place.

The production of light by inflammation is an object of great importance to society at large, as well as to the chemist. It appears to arise immediately from the strong ignition of a body while rapidly decomposing. Most solid bodies in combustion are kept, partly from a want of the access of air, and partly from the vicinity of conducting bodies, at a low degree of ignition. But when vapours rapidly escape into the air, it may, and does frequently happen, that the combustion, instead of being carried on at the surface of the mass, penetrates at a considerable depth within, and from this, as well as from the imperfect conducting power of the surrounding air, a white heat, or very strong ignition, is produced. The effect of lamps and candles depends upon these considerations. A combustible fluid, most commonly of the nature of fat oil, is put in a situation to be absorbed between the filaments of cotton, linen, fine wire, or asbestos. The extremity of this fibrous substance, called the wick, is then considerably heated. The oil evaporates, and its vapour takes fire. In this situation the wick, being enveloped with flame, is kept at such a temperature, that the oil continually boils, is evaporated, burns, and by these means keeps up a constant flame. Much of the perfection of this experiment depends on the nature, quantities, and figure, of the materials made use of. If the wick be too large, it

will supply a greater quantity of the fluid than can be well decomposed. Its evaporation will therefre diminish the temperature, and consequently the light, and afford a fuliginous column, which will pass through the centre of the flame, and fly off in the form of smoke. The magnitude of the wick may, from time to time, in candles, be reduced, as to length, by snuffing; but this operation will not remedy the evils which arise from too great a diameter. If the oil be not sufficiently combustible, the ignition will be but moderate, and the flame yellow; and the same effect will be produced, if the air be not sufficiently pure and abundant. An experiment to this effect may be made by including the flame of a small candle or lamp in a glass tube of about one inch in diameter, standing on the surface of a table. The air which passes between the glass and the table, will be sufficient to maintain a very bright flame; but if a metallic covering, perforated with a hole of about a quarter of an inch diameter, be laid upon the upper orifice of the tube, the combination will be so far impeded, that the flame will be perceptibly yellower. The hole may then be more or less closed at pleasure by sliding a small piece of metal, for example, a shilling, over it. The consequence will be, that the flame will become more and more yellow, will at length emit smoke, and, if the hole be entirely closed, extinction will follow.

The smell arising from the volatile parts, which pass off not well consumed from a lamp or candle, must be different according to the nature of those parts. This depends chiefly on the oil, but in some measure upon the wick. When a candle with a cotton wick is blown out, the smell is considerably more offensive, than if the wick be of linen, or of rush; but less offensive than if the supply of the combustion had been oil. Whenever a candle or lamp is removed, the combustion is in some measure impeded by the stream of cold air, against which it strikes. Smoke is accordingly emitted from its anterior side, and the peculiar smell is perceived. From this imperfection, lamps are much less adapted to be carried from place to place than candles.

From the necessity of the access of air, there will be more light produced from a lamp with a number of small wicks, than with one large one, or from a number of small candles, than the same quantity of tallow used to make a single large one. In the lamp of Argand, the wick consists of a web or cloth in the form of a pipe or tube, the longitudinal fibres of which are thicker than the circular ones. This is passed by a suitable contrivance into a cylindrical cavity, which contains the oil; and there are other precautions in the construction of the apparatus, by which the oil is regularly supplied, the access of air is duly permitted, as well within as without the circle formed by the upper edge of this cylindrical wick, and this edge can be raised or lowered at pleasure. Hence the possessor has it in his power to regulate the surface of the wick, so that the greatest flame consistent with perfect combustion may be produced; and the steadiness of the flame is secured by a glass shade or tube, which surrounds it, and in a certain degree accelerates the current of air.

In the illumination by candles, where the fused matter is contained in a cup or cavity of the matter not yet fused, it is of some consequence, whether the substance be fusible at a high or low temperature. The difference between wax and tallow candles arises from this property. Wax being less fusible, will admit of a thinner wick, and needs no snuffing; but in a tallow candle it is absolutely necessary to have a large wick, capable of taking up the tallow as it melts.

The difference of effect in illumination between a thick and a thin wick cannot be better shown, than by remarking the appearances produced by both. When a candle with a thick wick is first lighted, and the wick snuffed short, the flame is perfect and luminous, unless its diameter be very great; in which last case, there is an opake part in the middle, where the combustion is impeded for want of air. As the wick becomes longer, the space between its upper extremity and the apex of the flame is diminished; and consequently the oil, which issues from that extremity, having a less space of ignition to pass through, is less completely burned, and passes off partly in smoke. This evil continues to increase, until at length the upper extremity of the wick projects beyond the flame, and forms a support for an accumulation of soot, which is afforded by the imperfect combustion. A candle in this situation affords scarcely one tenth of the light, which the due combustion of its materials would produce; and tallow candles, on this account, require continual snuffing. But on the contrary, if we consider the wax-candle, we find, that as its wick lengthens, the light indeed becomes less, and the cup becomes filled with melted wax. The wick, however, being thin and flexible, does not long occupy its place in the centre of the flame; neither does it, when there, enlarge the diameter of the flame, so as to

prevent the access of air to its internal part. When its length is too great for the vertical position, it bends on one side; and its extremity, coming in contact with the air, is burned to ashes, excepting such a portion as is defended by the continual afflux of melted wax, which is volatilized and completely burned by the surrounding flame. We see, therefore, that the difficult fusibility of wax renders it practicable to burn a large quantity of fluid by means of a small wick; and that this small wick, by turning on one side in consequence of its flexibility, performs the operation of snuffing upon itself, in a much more accurate manner than it can ever be performed mechanically. Mr. Walker has suggested an ingenious contrivance to effect this in tallow candles. It consists in placing the candle in such a position, as to be inclined in an angle of about 30° from the perpendicular; by which means the wick will come out at the side of the flame when it is long enough to require snuffing, and there, burn to ashes. The light thus produced remaining nearly equable at all times, must be less injurious to the eyes.

Mr. Henry made some experiments on the light afforded by the combination of different gasses, and found, that it was apparently in the ratio of the oxigen that entered into combination with the hydrogen they contained. Thus 100 parts of pure hydrogen gas required from 50 to 54 of oxigen: 100 of gas from oak 42: from moist charcoal, and from dried peat, each 50: from lamp oil 136: from coal 140: from wax 166: pure olifiant gas 210. Tallow is nearly on a par with oil. The production of light from the first four was so trifling, that they did not appear applicable to economical purposes.

TALLOW (MINERAL). See BITUMEN.

TAMARINDS. The fruit of the tamarindus indica L. It is a pod resembling a bean-pod, including several hard seeds, together with a dark coloured viscid pulp, of a pleasant acid taste; the East India tamarinds are longer than the West India sort; the former containing six or seven seeds each, the latter rarely above three or four.

TAN OR TANNIN.
TANNING, (*the Art of*)

The general properties of tannin, particularly as connected with the art of tanning, under the articles LEATHER and GELATIN; and the properties of the compound of tannin, gallic acid, and extract, with various earthy and other salts, which exists in the infusion of astringent vegetables, have been given under the article GALLS, to all of which we must refer the reader. It will be proper however, in this place, slightly to recapitulate the general properties of tannin, the methods by which chemists have endeavoured to obtain it pure, and those by which its relative proportion to the other contents of astringent infusions, have been estimated. We shall also add an account of the late experiments, by which Mr. Hatchett has produced a substance, closely resembling tannin.

Mr. Biggins has made a great many experiments upon the quantity of tanning principle in various barks, from which he has constructed the following table.

	Tanning principle (in grs.) from half a pint of infusion, and an ounce of solution of glue.
Bark of elm	28
oak, cut in winter	30
horse-chesnut	30
beech	31
willow (boughs)	31
elder	41
plum-tree	58
willow (trunk)	52
sycamore	53
birch	54
cherry-tree	59
sallow	59
mountain-ash	60
poplar	76
hazel	79
ash	82
Spanish chesnut	98
smooth oak	104
oak, cut in spring	108
Huntingdon or Leicestershire willow	109
sumach	158

The substance called tan or tannin, is distinguished by its strong astringent taste, by a peculiar smell, by forming immediately with a solution of gelatin, a whitish compound insoluble in water and alcohol, and by uniting to animal skin, (which is chiefly gelatin in a condensed state,) immersed in it rendering it harder, less impervious to water, and no longer susceptible of putrefaction. These are the peculiar advantages procured by the art of tanning, which has been described under the article LEATHER.

Tannin is one of the immediate principles of vegetables, was first distinguished by Seguin from the gallic acid, with which it has been confounded under the name of the astringent principle. He gave it the name of tannin, from its use in the tanning of leather; which it effects by its characteristic property, that of forming

with gelatin, a tough and insoluble matter.

Proust who has made many researches on tannin, gives the following method of obtaining it, from the decoction of galls.

Pour into the decoction a solution of muriat of tin, which will give a copious yellow precipitate. Separate this by filtration, and when well washed, it will consist (as he asserts) of all the tannin united to the oxyd of tin. To separate these two, diffuse the precipitate in water, and pass a current of sulphuretted hydrogen gas, through the liquid. By degrees an insoluble hydro-sulphuret of tin will be precipitated, and the tannin now separated from the oxyd, will resume its solubility and dissolve in the fluid, giving it the acerb taste, and peculiar smell of the decoction of galls, after the excess of sulphuretted hydrogen has been expelled by boiling. This solution lathers like soap-water on agitation, and when concentrated by boiling, it deposits a brown powder on cooling, which is re-dissolved by heat. When evaporated to dryness, it leaves a dry, brown, friable, resinous looking mass, like aloes, which does not deliquesce, has an intensely acerb taste, re-dissolves in water and alcohol, and then gives an immediate precipitate with the solutions of gelatin, which is the most characteristic property of tannin.

The clear liquor that remains in the first part of this process, (that is after adding muriat of tin to the decoction of galls,) contains gallic acid, and muriat of tin.

Another method proposed by the same chemist of obtaining, what he conceived to be pure tannin, was to pour into an infusion of galls, a solution of potash thoroughly saturated with carbonic acid, such as the crystallized carbonate of potash is, which produces a yellowish white curdy precipitate, of the substance in question. The liquors should not be too dilute, nor the precipitate washed with too much water, as it is soluble in water, though sparingly. This precipitate dries slowly, but when spread over any smooth surface, in thin layers, and stoved, it becomes a brittle resinous yellow mass.—This substance distilled *per se*, gives a saline liquor, with an ammoniacal smell, which blackens the solutions of iron, and also a little thick butyraceous oil, and leaves a bulky coal.

Mr. Davy however, on repeating these experiments, found that this precipitate, did not exhibit the properties of pure tannin, as it wants the peculiar astringent taste, is but soluble in cold water and alcohol, and the solution is not precipitated by gelatin, till it is saturated with an acid. It also gives by incineration, a considerable quantity of carbonat of potash, and some carbonate of lime. It also affords gallic acid by distillation.

From these and other facts, it appears that this precipitate is not pure tannin, but is a very compounded substance, containing tannin, gallic acid, alkali and lime, and perhaps extract.

From all that has been done on this subject, it appears therefore that we cannot be certain, that we have ever obtained pure tannin, free from all other admixture ; and it is equally certain, that none of these methods, can extract the whole of this substance from vegetable infusions; so that it is still the best method, in experiments, where the quantity of tan alone is required, to make use of the infusion of animal gelatin, and estimate the quantity of tan, from the weight of the compound of tan and gelatin, thus produced.

With proper precautions, the gelatin only separates the tannin from the vegetable infusions ; and this compound appears tolerably uniform in its nature, and in the proportion of its constituent parts, though we have not been able to separate them, without destroying the characteristic properties of each.

In applying the solution of gelatin to infusions containing tannin, several circumstances must be noted. It appears, in the first place, that the mere dilution of the liquids, influences the quantity of precipitate, this being the greatest, in proportion as the solution of tannin is most concentrated.

The proportion of isinglass (*fish glue*) and water, employed by Mr. Davy, are 6 grains of the former to an ounce of liquid, which is nearly as strong as can be made at a moderate temperature, without being inconveniently stiff and gelatinous. Care must be taken, not to add an over proportion of gelatin, to the vegetable infusion, for when this happens, it appears that some of the compound is dissolved in the mixture, as less of it is precipitated. Probably therefore gelatin unites with tannin, in different proportions, and the compound is only insoluble, when the gelatin is in the inferior proportion. The precipitate should always be dried at a tolerably uniform temperature, somewhat higher than that of the atmosphere. This precipitate is composed, according to Mr Davy, on an average, of about 54 per cent. of gelatin, and 46 of tannin. There is much more tannin, however, in this com-

pound, than in tanned leather, or skin saturated with tannin, though the constituent parts are nearly the same.

It remains to mention a very curious production of tannin, by artificial means, from substances which do not naturally contain a particle of it, lately discovered by Mr. Hatchett, and partially noticed in this volume, under the article RESIN.

The ingenious author was led to the discovery, by pursuing his former experiments on bitumens and bovey coal, and in particular, on their habitudes with nitric acid. When a pure resin is digested with this acid, it is converted into an orange-coloured viscid substance, which at first separates, but by a further affusion of acid, is rendered soluble in water and alcohol.

On the other hand, when bitumen is treated in this manner, the first effect of the acid, is to separate this orange-yellow substance, and at the same time to produce a very dark brown solution. Now as the bitumens were shown by previous experiments, to consist of a resin, holding a portion of uncombined carbon, Mr. H. conceived that a separation of these two substances, was effected by the acid, and that the brown solution contained only the uncombined carbon, dissolved in nitric acid, whilst the orange-coloured mass was furnished by the resin. This was confirmed by treating in the same way, amber, asphaltum, different species of pit-coal, and lastly pure charcoal, all of which yielded the brown solution in abundance, particularly the charcoal, but only those substances that contained bitumen, deposited any of the orange coloured mass.—The charcoal therefore yielded none of this latter, but dissolved completely in the acid, making a dark reddish-brown liquid. This liquid was slowly evaporated to dryness, and left a brown glossy substance, with a resinous fracture.

In addition to the remarks heretofore made, on the art of tanning, the following additional observations of an author may be useful.

All the operations performed upon skins, preliminary to tanning them, consist in separating such matters, as are of a different nature, from the epidermis and the fibres, which constitute the skin, in order that the astringent principle may afterwards be combined, with these animal fibres. He next examines the different processes of the art of tanning, analyses their advantages and imperfections, and has succeeded in simplifying and abridging them, and by these means accelerating the return of capital, of which the investment constitutes a large part of the price of leather. With this view, his inquiries were directed to ascertain, what degree of heat is sufficient to extract the animal jelly, and also at what temperature the fibrous texture of the skin, begins to suffer alteration.

He ascertained, that the heat proper to dissolve the animal jelly commences at 140° Fahr. and that the fibrous texture is capable of sustaining a degree of heat beyond 167° Fahr. without undergoing any alteration, in places where the mean temperature of the barometer, is twenty-six inches and four lines, suppose French measure.

In consequence of his researches and observations, the author proposes to reduce the practice of the art of tanning to the following particulars:

1. The skins are to be kept separately immersed in running water, for a time sufficient to extract the lymph or serum. This period is easily ascertained, by putting a piece of the skin into a small quantity of water, and gradually heating it.—If it contains serum, this matter will be first extracted, and afterwards coagulated in the form of scum on the surface. If therefore no scum appear, the skins may be considered as purified, from lymphatic matter.

2. These washed and rinced skins are then to be transferred into boilers, properly adapted for the purpose: water is then to be added, and heat applied, so that the temperature of the water, may not exceed 60° Fahrenheit. The skins are to remain in this situation for an hour.

3. The skins are then to be taken out, and worked in the usual manner, to clear them of their impurities.

4. After this process they are again to be placed in the boiler, which must be so disposed, that a constant stream of water at the temperature of 167 degrees of Fahrenheit, shall enter by one cock, and pass off by another, on the opposite side beneath.

5. The skins are to remain in this situation, until the water that comes off, exhibits no vestige of animal jelly. This is easily ascertained, by evaporating a small quantity.

6. The skins are then to be taken out, and cleared in the usual manner of the cellular membrane, and fleshy parts.

7. Lastly, they are to be washed in running stream, and re-placed in a boiler, similar to that just mentioned, which is to be filled with the saturated decoction of tan, or oak bark. The same degree of heat is to be applied, as in the preceding operation, and the skins are to remain

until they are perfectly tanned. Fresh decoction of tan must be substituted from time to time, in the room of that which is exhausted. The exhausted state is shown by its not having power to afford a black, when a few drops of solution of sulphat of iron are added.

TANTALIUM.—This is a new metal, discovered by Mr. Eckeburg of Sweden, as he was examining a fossil containing yttria, with a view to ascertain the difference or identity of this earth and glucine. Beside this fossil, which he calls yttrotantalite, he has found another ore of tantalium, in which this metal is mixed with iron and manganese, and which he calls tantalite.

Tantalite is in detached crystals, of the size of a nut, approaching the octaedral form. It contains particles of feldspar and mica. Its surface is even, polished, and blackish. Fracture compact, of a metallic brilliancy, and not alike in colour all through, varying from a grayish blue to the black of iron. Powdered, it is of a blackish gray, approaching to brown. It gives sparks with steel. Specific gravity 7.953. Its gangue is composed of white quartz and mica, with veins of red feldspar. These crystals had been considered as a variety of the garnet-shaped tin ore.

The yttrotantalite was found in the same place and gangue as gadolinite; in small nodules, not so large as a nut, thinly encrusted with feldspar. Its fracture is granulated, of the black colour of iron, with a metallic brilliancy. When in powder it is grayish. It is not attracted by the magnet. It may be scraped with a knife, though with difficulty. Specific gravity 5.13; though no doubt it would be more, if totally free from feldspar.

Tantalium is characterized by its insolubility in all the acids. The only reagent that has any action on it, is caustic fixed alkali. When exposed to the fire with this, and the mass afterward lixiviated, it partly dissolves in water, and may be precipitated by means of an acid; but the precipitate is not in the least attacked, whatever the quantity of acid employed. Separated by filtration, and dried, it is an extremely white powder, the colour of which is not changed by a red heat. The remainder of the mass, being treated with acids, affords the same powder. Specific gravity after ignition 6.5 It is fusible with the blow-pipe by the addition of an alkaline phosphat and borat of soda, but it does not impart any colour to the flux.

Exposed to a strong heat in a crucible with powdered charcoal, it is reduced to a moderately hard button, having a metallic brilliancy at its surface; but its fracture is dull and blackish. The acids have no other action on it, than converting it to a white oxide.

TAP-COCK. See Pneumatic cock.

TAR. See Turpentine.

TAR, *Mineral*. See Bitumen.

TARRAS, or *Terras*, a volcanic earth used as a cement. It does not differ much in its principles from puzzolana; but it is much more compact, hard, porous, and spongy. It is generally of a whitish-yellow colour, and contains more heterogeneous particles, as spar, quartz, schoerl, &c., and something more of a calcareous earth. It effervesces with acids, is magnetic, and fusible per se. When pulverized, it serves as a cement, like puzzolana. It is found in Germany and Sweden.

When reduced to powder, and mixed with water, Teras forms a most durable cement, or mortar, which is advantageously employed for lining basons, cisterns, &c.

Mr More states, that *red earth* is an excellent substitute for Tarras, in all buildings under water. Thus, if one measure of such earth be mixed with an equal portion of sand, and a double quantity of well-slaked lime, the whole will form a cement, excellently adapted for constructing dams, bridges, or any other edifice in water, as it speedily hardens, and acquires the durability of stone.

A mixture of lime, and fine gravel, called *grout* by the masons, is also useful for the same purpose. See Cement.

TARTAR.—Tartar is deposited on the sides of casks during the fermentation of wine: it forms a lining more or less thick, which is scraped off. This is called crude tartar, and is sold in Languedoc from 10 to 15 livres the quintal.

All wines do not afford the same quantity of tartar. Neumann remarked, that the Hungarian wines left only a thin stratum; that the wines of France afforded more; and that the Rhenish wines afforded the purest and the greatest quantity.

Tartar is distinguished from its colour into red and white; the first is afforded by red wine.

Tartar is purified from an abundant extractive principle, by processes which are executed at Montpellier, and at Venice.

The following is the process used at Montpellier: The tartar is dissolved in water, and suffered to crystallize by cooling. The crystals are then boiled in another vessel, with the addition of five or

six pounds of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling with the earth, a very white salt is obtained by evaporation, which is known by the name of cream of tartar, or the acidulous tartrite of potash.

Mr. Desmarets has informed us, that the process used at Venice consists,

1. In drying the tartar in iron boilers.

2. Pounding it, and dissolving it in hot water, which by cooling affords purer crystals.

3. Redissolving these crystals in water, and clarifying the solution by whites of eggs and ashes.

The process of Montpellier is preferable to that of Venice. The addition of the ashes introduces a foreign salt, which alters the purity of the product. See Argol.

Tartar is called supertartrite of potash, purified tartar, crystals of tartar, &c. It is used in the arts and in medicine.

TARTAR, *Salt of*. See Potash.

TARTAROUS ACID.—The casks in which some kinds of wine are kept become incrusted with a hard substance, tinged with the colouring matter of the wine, and otherwise impure, which has long been known by the name of *argal*, or tartar, and distinguished into red, and white, according to its colour. This being purified by solution, filtration, crystallization, was termed *cream*, or *crystals of tartar*. It was afterward discovered, that it consisted of a peculiar acid, combined with potash: and the supposition that it was formed during the fermentation of the wine, was disproved by Boerhaave, Neumann and others, who showed that it existed ready formed in the juice of the grape. It has likewise been found in other fruits, particularly before they are too ripe; and in the tamarisk, sumac, balm, carduus benedictus, and the roots of rest-harrow, germander, and sage. The separation of tartarous acid from this acidulous salt, is the first discovery of Scheele that is known. He saturated the superfluous acid by adding chalk to a solution of the supertartrite in boiling water as long as any effervescence ensued, and expelled the acid from the precipitated tartrite of lime by means of the sulphuric. Fourcroy observes, that by using lime instead of its carbonat, the whole of the tartarous acid may be obtained; and the supernatant liquor will then contain pure potash, instead of the neutral tarrtrite of potash, which it holds in solution when chalk is used. Or four parts of tartar may be boiled in twenty or twenty-four of water, and one part of sulphuric acid added gradually. By continuing the boiling, the sulphat of potash will fall down. When the liquor is reduced to one half, it is to be filtered, and if any more sulphat be deposited by continuing the boiling, the filtering must be repeated. When no more is thrown down, the liquor is to be evaporated to the consistence of a syrup, and thus crystals of tartarous acid equal to half the weight of the tartar employed, will be obtained.

The tartarous acid may be procured in needly or laminated crystals, by evaporating a solution of it. Its taste is very acid and agreeable, so that it may supply the place of lemon juice. It is very soluble in water. Burnt in an open fire it leaves a coaly residuum, generally containing a little lime: in close vessels it gives out carbonic acid and hydrogen gas, so that its base is a compound of hydrogen and carbon. By distilling nitric acid off the crystals they may be converted into oxalic acid, and the nitric acid passes to the state of nitrous.

TELLURIUM.—Tellurium is a new metal discovered by Klaproth, in the year 1797. It is found in three different ores; namely, 1. In the *white gold ore of Fatzebay*, formerly named *aurum paradoxum*, found in the mine called Maria-hilf, in the mountains of Fatzebay, in Transylvania. In this ore tellurium exists alloyed with gold and iron. Its colour is between tin-white and lead-gray. It is in general found massive. The texture of this ore is granular, and its lustre considerably metallic. 2. In the *graphic gold ore*, (*aurum graphicum*) of Offenbanya, it is alloyed with gold and silver. This ore is composed of flat prismatic crystals, the arrangement of which has some resemblance to Turkish letters; hence the name of the ore. It has a metallic lustre, and a tin-white colour, with a tinge of brass yellow. 3. It exists also in the ore known under the name of the *yellow foliated gold ore of Nagzag*, alloyed with gold, lead, silver, copper, and sulphur.

Tellurium is obtained, according to Klaproth, by forming oxyd of tellurium into a paste, with a few drops of linseed oil, and then putting it into a small glass retort or crucible. As the oil becomes decomposed, brilliant and metallic drops are observed on the upper part of the vessel, which increase in number until the oxyd is revived.

The process for obtaining oxyd of tellurium may be seen in the following analysis.

Let the white gold ore be gently heated with six parts of muriatic acid; three

parts of the nitric being then added, the mixture is boiled, upon which there arises a considerable effervescence, and a complete solution is obtained. The filtered solution must be diluted with as much water as it can bear without becoming turbid, which is a very small quantity; and a solution of potash is then to be added to the liquor, until the white precipitate, which is at first formed disappears, and nothing remains but a brown flaky sediment, which is the oxyd of gold mixed with the oxyd of iron contained in the ore. This may be dissolved in nitro-muriatic acid, and the gold be precipitated by a solution of nitrate of mercury, and then the iron by potash. Muriatic acid is then added to the before obtained alkaline solution, in sufficient quantity to saturate the potash. An excess of the acid must be avoided. A white precipitate is thus produced in great abundance. This when washed, is the oxyd of tellurium.

TEMPERING.—Cutting instruments of steel, after being finished, are hardened by heating them to a cherry red, and then plunging them into a cold liquid. After this hardening, it is necessary to soften them a little, or to *temper* them as it is called, in order to obtain a fine and desirable edge. This is done by heating them till some particular colour appears on their surface. The usual way is to keep them in oil, heated to a particular temperature, till the requisite colour appear. These colours follow one another in regular succession. Between 430 degrees and 450 degrees, the instrument appears of a pale yellow tinge; at 460 degrees the colour is a straw yellow, and the instrument has the usual temper of penknives, razors, and other fine-edged tools. At 500 degrees, a brownish metallic yellow is given. As the heat increases, the surface is successively yellow, brown red, and purple, to 580 degrees, when it becomes of a uniform deep blue, like that of watch springs. The blue gradually weakens to a water colour, which is the last shade distinguishable before the instrument becomes red hot.

TENNANT'S BLEACHING POWDER. See BLEACHING, and Appendix to vol. i.

TERRA LEMNIA. A red bolar earth.

TERRA MERITA. See TURMERIC.

TERRA PONDEROSA, *Barytes*. See EARTHS.

TERRA SIENNA.—A brown bole, or ochre, with an orange cast, brought from Sienna in Italy, and used in painting, both raw and burnt. When burnt it becomes of a darker brown. It resists the fire a long time without fusing. It adheres to the tongue very forcibly. See COLOUR-MAKING.

TERRA SIGILLATA. When the boles were much more esteemed for medical purposes than they are at present, and supposed to differ considerably in their virtues, some of them were impressed with a seal, as of particular excellence, and hence called *sealed earths*.

TERRAS. See TARRAS.

TERRE VERTE.—This is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes with chalk and pyrites; alum and sulphat of lime are also accidentally found with it. It is difficultly soluble in acids, is not magnetic before calcination, and becomes of a coffee-colour when heated. It is said to afford about 40 per cent. of iron.

TESTS, *Reagents*.—The number of articles which are used for experiments, analyses, &c. by chemists. in order to effect decompositions, and compositions, and to determine the presence or absence of certain bodies, are called tests, or reagents. They are "the compass by which the chemist steers." It is obvious, that as reagents effect new changes, and as these changes are determined by the laws of affinity, their number must be great, as well as their effects various. It is by a knowledge of these facts, that the accuracy of an analysis, or examination, is determined.

The following remarks, accompanying a catalogue of the most necessary tests, for the examination of mineral waters in particular, we extract from Henry's Chemistry, 8vo. page 309.

"The use of tests, or re-agents, has been employed by Mr. Kirwan, to ascertain, by a careful examination of the precipitate, not only the *kind*, but the *quantity*, of the ingredients of mineral waters. This will be best understood from an example. It is an established fact, that 100 parts of crystallized muriate of soda, when completely decomposed by nitrate of silver, yield, as nearly as possible, 235 of precipitate. From the weight of the precipitate, separated by nitrat of silver from a given quantity of any water, it is therefore easy, when no other muriatic salt is present, to infer, what quantity of muriate of soda was contained in the water; since every hundred grains of muriated silver indicate, pretty accurately, 42½ of crystallized common salt. The same mode of estimation may be applied in various other instances; and the rule for each individual case, is given by Mr. Kirwan, in part ii, chap. ii, of his Essay on the Analysis of Mineral Waters. In most instances, also, it will be found stated in

the following description of the use of the various re-agents.

I. *Infusion of Litmus, Syrup of Violets, &c.*

The infusion of litmus is prepared by steeping this substance, first bruised in a mortar, and tied up in a thin rag, in distilled water, which extracts its blue colour.

If the colour of the infusion tends too much to purple, it may be amended by a drop or two of solution of pure ammonia; but of this no more must be added than is barely sufficient, lest the delicacy of the test should be impaired.

The syrup of violets is not easily obtained pure. The genuine syrup may be distinguished from the spurious by a solution of corrosive sublimate, which changes the former to green, while it reddens the latter. When it can be procured genuine, it is an excellent test of acids, and may be employed in the same manner as the infusion of litmus.

Paper stained with the juice of the March violet, or with that of the scrapings of radishes, answers a similar purpose. In staining poper for the purposes of a test, it must be used unsized; or, if sized, it must previously be well washed with warm water; because the alum, which enters into the composition of the size, will otherwise change the vegetable colour to red.

In the Philosophical Magazine, vol. 1, p. 180, may be found some recipes for test liquors, invented by Mr. Watt.

Infusion of litmus is a test of most uncombined acids.

1. If the infusion redden the unboiled, but not the boiled water, under examination or if the red colour, occasioned by adding the infusion to a recent water, return to blue, on boiling; we may infer, that the acid is a volatile one, and most probably the carbonic acid. Sulphuretted hydrogen gas, dissolved in water, also reddens litmus, but not after boiling.

2. To ascertain whether the change be produced by carbonic acid, or by sulphuretted hydrogen, when experiment shows that the reddening cause is volatile, add a little lime water, or in preference, barytic water. This, if carbonic acid be present, will occasion a precipitate, which will dissolve, with effervescence, on adding a little muriatic acid. Sulphuretted hydrogen may also be contained, along with carbonic acid, in the same water; which will be determined by the tests hereafter to be described.

3. Paper tinged with litmus is also reddened by the presence of carbonic acid, but regains its blue colour on drying. The mineral and fixed acids redden it permanently. That these acids, however, may produce their effect, it is necessary that they should be present in a sufficient proportion. (See Kiwan on Mineral Waters, p. 40.) The dark-blue paper, which is generally wrapped round loaves of refined sugar, is not discoloured by carbonic acid or sulphuretted hydrogen, but only by the stronger acids.

II. *Infusion of Litmus reddened by Vinegar,—Tincture of Brasil-wood,—Tincture of Turmeric, and Paper stained with each of these three Substances,—Syrup of Violets.*

All these different tests have one and the same object.

1. Infusion of litmus reddened by vinegar, or litmus paper reddened by vinegar, has its blue colour restored by pure alkalies and pure earths, and by carbonated alkalies and earths.

2. Turmeric paper and tincture are changed to a reddish-brown by alkalies, whether pure or carbonated, and by pure earths, but not by carbonated earths.

3. The red infusion of brazil-wood, and paper stained with it, become blue by alkalies and earths, and even by the latter, when dissolved by an excess of carbonic acid. In the last-mentioned case, however, the change will either cease to appear, or will be much less remarkable, when the water has been boiled.

4. Syrup of violets, when pure, is, by the same causes, turned green; as is also paper stained with the juice of the violet, or with the scrapings of radishes.

According to Mr. Accum, syrup of violets, which has lost its colour by keeping, may be restored by agitation, during a few minutes, in contact with oxygen gas.

III. *Tincture of Galls.*

Tincture of galls is the test generally employed for discovering iron; with all combinations of which it produces a black tinge, more or less intense according to the quantity of iron. The iron, however, in order to be detected by this test, must be in the state of red oxyde, or, if oxydized in a less degree, its effect will not be apparent, unless after standing some time in contact with the air. By applying this test before and after evaporation, or boiling, we may know whether the iron be held in solution by carbonic acid, or by a fixed acid. For,

1. If it produce its effect before the application of heat, and not afterward, carbonic acid is the solvent.

2. If after, as well as before, a mineral acid is the solvent.

3. If, by the boiling, a yellowish powder be precipitated, and yet galls continue to strike the water black, the iron, as often happens, is dissolved both by carbonic acid and by a fixed acid. A neat mode of applying the gall test was used by M. Klaproth, in his analysis of the Carlsbad water; a slice of the gall-nut was suspended by a silken thread in a large bottle of the recent water, and so small was the quantity of iron, that it could only be discovered in water fresh from the spring, by a slowly-formed and dark cloud, surrounding the re-agent. (Klaproth, vol. i, p. 279.)

IV. *Sulphuric Acid.*

1. Sulphuric acid discovers, by a slight effervescence, the presence of carbonic acid, whether uncombined or united with alkalies or earths.

2. If lime be present, whether pure or uncombined, the addition of sulphuric acid occasions, after a few days, a white precipitate.

3. Barytes is precipitated instantly, in the form of a white powder.

4. Nitric and muriatic salts, in a dry state, or dissolved in very little water, on adding sulphuric acid, and applying heat, are decomposed; and if a stopper, moistened with solution of pure ammonia, be held over the vessel, white clouds will appear. For distinguishing whether nitric or muriatic acid be the cause of this appearance, rules will be given hereafter.

V. *Nitric and Nitrous Acids.*

These acids, if they occasion effervescence, give the same indications as the sulphuric. The nitrous acid has been recommended as a test distinguishing between hepatic waters that contain hydrosulphuret of potash, and those that contain only sulphuretted hydrogen gas. In the former case, a precipitate ensues on adding nitrous acid, and a very fetid smell arises; in the latter, a slight cloudiness only appears, and the smell of the water becomes less disagreeable.

VI. *Oxalic Acid and Oxalates.*

This acid is a most delicate test of lime, which it separates from all its combinations.

1. If a water, which is precipitated by oxalic acid, become milky on adding a watery solution of carbonic acid, or by blowing air through it from the lungs, by means of a quill or glass tube, we may infer, that pure lime (or barytes, which has never yet been found pure in waters) is present.

2. If the oxalic acid occasion a precipitate before, but not after boiling, the lime is dissolved by an excess of carbonic acid;

3. If after boiling, by a fixed acid. A considerable excess of any of the mineral acids, however, prevents the oxalic acid from occasioning a precipitate, even though lime be present; because some acids decompose the oxalic, and others, dissolving the oxalate lime, prevent it from appearing. (Vid. Kirwan on Waters, p. 88.)

The oxalate of ammonia, or of potash (which may easily be formed by saturating the respective carbonates of these alkalies with a solution of oxalic acid), are not liable to the above objection, and are preferable, as re-agents, to the uncombined acid. Yet even these oxalates fail to detect lime when supersaturated with muriatic or nitric acids; and, if such an excess be present, it must be saturated, before adding the test, with pure ammonia. A precipitation will then be produced.

The quantity of lime, contained in the precipitate, may be known, by first calcining it with access of air, which converts the oxalate into a carbonate; and by expelling, from this last, its carbonic acid, by calcination, with a strong heat, in a covered crucible. According to Dr. Marcet, 117 grains of sulphate of lime give 100 of oxalate of lime, dried at 160° Fahrenheit.

The fluate of ammonia, recommended by Scheele, I find to be a most delicate test of lime. It may be prepared by adding carbonate of ammonia to diluted fluoric acid, in a leaden vessel, observing that there be a small excess of acid.

VII. *Pure Alkalies and carbonated Alkalies.*

1. The pure fixed alkalies precipitate all earths and metals, whether dissolved by volatile or fixed menstrua, but only in certain states of dilution; for example, sulphate of alumine may be present in water, in the proportion of 4 grains to 500, without being discovered by pure fixed alkalies. As the alkalies precipitate so many substances, it is evident that they cannot afford any very precise information, when employed as re-agents. From the colour of the precipitate, as it approaches to a pure white, or recedes from it, an experienced eye will judge, that the precipitated earth contains less or more of metallic admixture; and its precise composition must be ascertained by rules which will presently be given.

2. Pure fixed alkalies also decompose all salts with basis of ammonia, which becomes evident by its smell (except the salts are dissolved in much water), and also by the white fumes it exhibits when a stopper, moistened with muriatic acid, is brought near.

3. Carbonates of potash and of soda have similar effects.

4. Pure ammonia precipitates all earthy and metallic salts. Besides this property, it also imparts a deep blue colour to any liquid that contains copper or nickel in a state of solution.

5. Carbonate of ammonia has the same properties, except that it does not precipitate magnesia from its combinations. Hence, to ascertain whether this earth be present in any solution, add the carbonate of ammonia till no farther precipitation ensues; filter the liquor; raise it nearly to 212° Fahrenheit; and then add pure ammonia. If any precipitation now occurs, we may infer the presence of magnesia. It must be acknowledged, that zircon, yttria, and glucine, would escape discovery by this process; but they have never yet been found in mineral waters; and their presence can scarcely be expected.

VIII. *Lime-Water.*

1. Lime-water is applied to the purposes of a test, chiefly for detecting carbonic acid. Let any liquor supposed to contain this acid be mixed with an equal bulk of lime-water. If carbonic acid be present, either free or combined, a precipitate will immediately appear, which, on adding a few drops of muriatic acid, will again be dissolved with effervescence.

2. Lime-water will also show the presence of corrosive sublimate by a brick-dust-coloured sediment. If arsenous acid (common arsenic) be contained in a liquid, lime-water, when added, will occasion a precipitate, consisting of lime and arsenous acid, which is very difficultly soluble in water. This precipitate, when mixed up with oil, and laid on hot coals, yields the well known garlic smell of arsenic.

IX. *Pure Barytes, and its Solution in Water.*

1. A solution of pure barytes is even more effectual than lime-water in detecting the presence of carbonic acid, and is much more portable and convenient; since, from the crystals of this earth, the barytic solution may at any time be immediately prepared. In discovering carbonic acid, the solution of barytes is used similarly to lime-water, and, if this acid be present, gives, in like manner, a precipitate soluble with effervescence in dilute muriatic acid.

2. The barytic solution is also a most sensible test of sulphuric acid and its combinations, which it indicates by a precipitate not soluble in muriatic acid.—Pure strontites has similar virtues as a test. The quantity of the precipitated substance, indicated by the weight of the precipitate, will be stated in No. XV.

X. *Metals.*

1. Of the metals, silver and mercury are tests of the presence of hydro-sulphurets, and of sulphuretted hydrogen gas. If a little quick-silver be put into a bottle containing water impregnated with either of these substances, its surface soon acquires a black film, and, on shaking the bottle, a blackish powder separates from it. Silver is speedily tarnished by the same cause.

2. Metals may be used also as tests of each other, on the principle of elective affinity. Thus, for example, a polished iron plate, immersed in a solution of sulphate of copper, soon acquires a coat of this metal; and the same in other similar examples.

XI. *Sulphate of Iron.*

This is the only one of the sulphates, except that of silver, applicable to the purposes of a test. When used with this view, it is generally employed for ascertaining the presence of oxygen gas, of which a natural water may contain a small quantity.

A water, suspected to contain this gas, may be mixed with a little recently-dissolved sulphate of iron, and kept corked up, in a vial completely filled by the mixture. If an oxide of iron be precipitated in the course of a few days, the water may be inferred to contain oxygen gas.

XII. *Sulphate, Nitrate, and Acetate of Silver.*

These solutions are all, in some measure, applicable to the same purpose.

1. They are peculiarly adapted to the discovery of muriatic acid and of muriates. For the silver, quitting its solvent, combines with the muriatic acid, and forms a flaky precipitate, which, at first, is white, but, on exposure to the sun's light, acquires a blueish, and finally a black colour. This precipitate Dr. Black states to contain, in 1000 parts, as much muriatic acid as would form 425½ of crystallized muriate of soda, which estimate scarcely differs at all from that of Klaproth. The same quantity of muriate of silver (1000 parts) indicates, according to

Kirwan, 454¾ of muriate of potash. A precipitation, however, may arise from other causes, which it may be proper to state.

2. The solutions of silver in acids are precipitated by carbonated alkalies and earths. The agency of the alkalies and earths may be prevented, by previously saturating them with a few drops of the same acid in which the silver is dissolved.

3. The nitrate and acetate of silver are decomposed by the sulphuric and sulphurous acids; but this may be prevented by adding, previously, a few drops of nitrate or acetite of barytes, and, after allowing the precipitate to subside, the clear liquor may be decanted, and the solution of silver added. Should a precipitation now take place, the presence of muriatic acid, or some one of its combinations, may be suspected. To remove uncertainty, whether a precipitation be owing to sulphuric or muriatic acid, a solution of sulphate of silver may be employed, which, when no uncombined alkali or earth is present, is affected only by the latter acid. According to professor Pfaff, one part of muriatic acid of the specific gravity, 1.15, diluted with 70,000 parts of water, barely exhibits a slight opaline tinge, when tested with nitrate of silver; and, when diluted with 80,000 parts of water, it is not affected at all.

4. The solutions of silver are also precipitated by sulphuretted hydrogen, and by hydro-sulphurets; but the precipitate is then reddish, or brown, or black; or it may be, at first, white, and afterwards become speedily brown or black. It is soluble, in great part, in dilute nitrous acid, which is not the case if occasioned by muriatic or sulphuric acid.

5. The solutions of silver are precipitated by extractive matter; but, in this case, also, the precipitate has a dark colour, and is soluble in nitrous acid.

XIII. *Nitrate and Acetate of Lead.*

1. Acetate of lead, the most eligible of these two tests, is precipitated by sulphuric and muriatic acids; but, as of both these we have much better indicators, I do not enlarge on its application to this purpose.

2. The acetate is also a test of sulphuretted hydrogen and of hydro-sulphurets of alkalies, which occasion a black precipitate; and, if a paper, on which characters are traced with a solution of acetate of lead, be held over a portion of water containing sulphuretted hydrogen gas, they are soon rendered visible; especially when the water is a little warmed.

3. The acetate of lead is employed in the discovery of uncombined boracic acid, a very rare ingredient of waters. To ascertain whether this be present, some cautions are necessary. (*a*.) The uncombined alkalies and earths (if any be suspected) must be saturated with acetic or acetous acid. (*b*.) The sulphates must be decomposed by acetate or nitrate of barytes, and the muriates by acetate or nitrate of silver. The filtered liquor, if boracic acid be contained in it, will continue to give a precipitate, which is soluble in nitric acid of the specific gravity 1.3.

4. Acetate of lead is said, also, by Pfaff, to be a very delicate test of carbonic acid; and that it renders milky, water which contains the smallest quantity of this acid.

XIV. *Nitrate of Mercury, prepared with and without Heat.*

This solution, differently prepared, is sometimes employed as a test.

1. The solution of nitrate of mercury, prepared without heat, has been found by Pfaff to be a much more sensible test of muriatic acid, than nitrate of silver. Its sensibility, indeed, is so great, that one part of muriatic acid, of the specific gravity 1.50 diluted with 300,000 parts of water, is indicated by a slightly dull tint ensuing on the addition of the test.

2. It is, at the same time, the most sensible test of ammonia, one part of which, with 30,000 parts of water, is indicated by a slight blackish yellow tint, on adding the nitrate of mercury.

3. The nitrate of mercury is also precipitated by highly diluted phosphoric acid; but the precipitate is soluble in an excess of phosphoric or nitric acid, which is not the case if it has been occasioned by muriatic acid.

XV. *Muriate, Nitrate; and Acetate of Barytes.*

1. These solutions are all, most delicate tests of sulphuric acid and of its combinations, with which they give a white precipitate, insoluble in dilute muriatic acid. They are decomposed, however, by carbonates of alkali; but the precipitate occasioned by carbonates is soluble in dilute muriatic, or nitric acid, with effervescence, and may even be prevented by adding, previously, a few drops of the same acid as that contained in the barytic salt, which is employed.

One hundred grains of dry sulphate of barytes contain (according to Klaproth, vol. i. p. 168.) about 45⅓ of sulphuric acid of the specific gravity 1850; according to Clayfield (Nicholson's Journal, 4to. iii 38.) 33 of acid, of specific gravity 2240;

according to Thenard, after calcination, about 25; and, according to Mr. Kirwan, after ignition, 23.5 of real acid. The same chemist states, that 170 grains of ignited sulphate of barytes denote 100 of dried sulphate of soda; while 136.36 of the same substance indicate 100 of dry sulphate of potash; and 100 parts result from the precipitation of 52.11 of sulphate of magnesia.

From Klaproth's experiments, it appears, that 1000 grains of sulphate of barytes indicate 595 of desiccated sulphate of soda, or 1416 of the crystallized salt The same chemist has shown, that 100 grains of sulphate of barytes are produced by the precipitation of 71 grains of sulphate of lime.

2. Phosphoric salts occasion a precipitate also, which is soluble in muriatic acid without effervescence.

XVI. *Prussiates of Potash and of Lime.* Of these two, the prussiate of potash is the most eligible. When pure, it does not speedily resume a blue colour on the addition of an acid, nor does it *immediately* precipitate muriate of barytes.

Prussiate of potash is a very sensible test of iron, with the solutions of which in acids it produces a Prussian blue precipitate, in consequence of a double elective affinity. To render its effect more certain, however, it may be proper to add, previously, to any water suspected to contain iron, a little muriatic acid, with a view to the saturation of uncombined alkalies or earths, which, if present, prevent the detection of very minute quantities of iron.

1. If a water, after boiling and filtration, does not afford a blue precipitate, on the addition of prussiate of potash, the solvent of the iron may be inferred to be a volatile one, and probably the carbonic acid.

2. Should the precipitation ensue in the boiled water, the solvent is a fixed acid, the nature of which must be ascertained by other tests.

In using the prussian test for the discovery of iron, considerable caution is necessary, in order to attain accurate results. The prussiate should, on all occasions, be previously crystallized; and the quantity of oxide of iron, essential to its constitution, or at least an invariable accompaniment, should be previously ascertained in the following manner. Expose a known weight of the crystallized salt to a low red-heat in a silver crucible. Affusing and boiling up, it will become dry, and will then blacken. Let it cool; wash off the soluble part; collect the rest on a filter; dry it, and again calcine it with a little wax. Let it be again weighed, and the result will show the proportion of oxide of iron present in the salt which has been examined. This varies from 22 to 30 and upwards per cent. When the test is employed for discovering iron, let a known weight of the salt be dissolved in a given quantity of water; add the solution gradually; and observe how much is expended in effecting the precipitation. Before collecting the precipitate, warm the liquid, which generally throws down a further portion of prussian blue. Let the whole be washed and dried, and then calcined with wax. From the weight of the oxide obtained, deduct that quantity which, by the former experiment, is known to be present in the prussiate that has been added; and the remainder will denote the quantity of oxide of iron, present in the liquid which is under examination.

3. Besides iron, the prussiated alkalies also precipitate muriate of alumine. No conclusion, therefore, can be deduced, respecting the non-existence of muriate of alumine from any process, in which the prussic test has previously been used. It will, therefore, be proper, if a salt of alumine be indicated by other tests, to examine the precipitate effected by prussiate of potash. This may be done by repeatedly boiling it to dryness with muriatic acid, which takes up the alumine, and leaves the prussiate of iron. From the muriatic solution, the alumine may be precipitated by a solution of carbonate of potash.

4. According to Klaproth (ii. 55.) solutions of yttria, (which earth, however, is not likely to be present in any mineral water) afford with the prussian test, a white precipitate, passing to pearl-gray, which consists of prussiate of yttria. This precipitate disappears on adding an acid, and hence may be separated from prussiated iron. The same accurate chemist states, that the prussian test has no action on salts with base of glucine (ib.); but that it precipitates zircon from its solutions. (ii. 214.)

The prussiated alkalies decompose, also, all metallic solutions, excepting those of gold, platina, iridium, rhodium, osmium, and antimony.

XVII. *Succinate of Soda and Ammonia.*

1. The succinate of soda was first recommended by Gehlen, and afterwards employed by Klaproth (Contributions, II, 48.) for the discovery and separation of iron. The salt with base of ammonia has also been used for a similar purpose by

Dr. Marcet, physician to Guy's Hospital, in a skilful analysis of the Brighton chalybeate, which is published in the new edition of Dr. Saunders's Treatise on Mineral Waters.

The succinic test is prepared by saturating carbonate of soda or ammonia with this acid. In applying the test, it is necessary not to use more than is sufficient for the purpose; because an excess of it re-dissolves the precipitate. The best mode of proceeding, is to heat the solution containing iron, and to add gradually the solution of succinate, until it ceases to produce any effect. A brownish precipitate is obtained, consisting of succinate of iron This, when calcined with a little wax, in a low red heat, gives an oxide of iron, containing about 70 per cent of the metal. From Dr. Marcet's experiments, it appears, that 100 grains of iron, dissolved in sulphuric acid, then precipitated by the succinate test, and afterwards burned with wax, gave 148 of oxide of iron; that is, 100 grains of the oxide indicate about 67½ of metallic iron.

2. The succinates, however, it is stated by Dr. Marcet and Mr. Ekeberg, precipitate alumine, provided there be no considerable excess of acid in the aluminous salt. On magnesia it has no action, and hence may be successfully employed in the separation of these two earths. If 100 parts of octaedral crystals of alum be entirely decomposed by succinate of ammonia, they give precisely 12 parts of alumine calcined in a dull red heat. The succinate of ammonia, it is stated by Mr. Ekeberg (Journ. des Mines, No. 70.) precipitates glucine; and the same test, according to Klaproth, (II, 214.) throws down zircon from its solutions.

XVIII. *Phosphate of Soda.*

An easy and valuable method of precipitating magnesia has been suggested by Dr. Wollaston. It is founded on the property which fully neutralized carbonate of ammonia possesses; first to dissolve the carbonate of magnesia, formed when it is added to the solution of a magnesian salt, and afterwards to yield the earth to phosphoric acid, with which and ammonia it forms a triple salt For this purpose, a solution of carbonate of ammonia, prepared with a portion of that salt which has been exposed, spread on a paper, for a few hours to the air, is to be added to the solution of the magnesian salt sufficiently concentrated; or to a water suspected to contain magnesia, after being very much reduced by evaporation. No precipitate will appear, till a solution of phosphate of soda is added, when an abundant one will fall down. Let this be dried in a temperature not exceeding 100 degrees of Fahrenheit. One hundred grs. of it will indicate 19 of pure magnesia, or about 64 of muriate of magnesia.

XIX. *Muriate of Lime.*

Muriate of lime is principally of use in discovering the presence of alkaline carbonates, which though they very rarely occur, have sometimes been found in mineral waters. Carbonate of potash exists in the waters of Aix-la-Chapelle; that of soda, in the water of a few springs and lakes; and the ammoniacal carbonate was detected by Mr. Cavendish in the waters of Rathbone-place. Of all the three carbonates, muriate of lime is a sufficient indicator; for those salts separate from it a carbonate of lime, soluble with effervescence in muriatic acid.

With respect to the discrimination of the different alkalies, potash may be detected by the nitro muriate of platina, which distinctly and immediately precipitates that alkali and its compounds, and is not affected by soda. Carbonate of ammonia may be discovered by its smell, and by its precipitating a neutral salt of alumine, while it has no action apparently on magnesian salts.

To estimate the proportion of an alkaline carbonate present in any water, saturate with sulphuric acid, and note the weight of real acid which is required. Now 100 grains of real sulphuric acid saturate 121.48 potash, and 78.32 soda.

XX. *Solution of Soap in Alcohol.*

This solution may be employed to ascertain the comparative hardness of waters. With distilled water it may be mixed, without any change ensuing; but if added to a hard water, it produces a milkiness, more considerable as the water is less pure; and, from the degree of this milkiness, an experienced eye will derive a tolerable indication of the quality of the water. This effect is owing to the alkali quitting the oil, whenever there is present in a water any substance, for which the alkali has a stronger affinity than it has for oil. Thus all uncombined acids, and all earthy and metallic salts, decompose soap, and occasion that property in waters which is termed hardness.

XXI. *Alcohol.*

Alcohol, when mixed with any water, in the proportion of about an equal bulk, precipitates all the salts which it is incapable of dissolving. (See Kirwan on Waters, p. 263.)

XXII. *Hydro-sulphuret of Ammonia.*

This and other sulphurets, as well as water saturated with sulphuretted hydrogen, may be employed in detecting lead and arsenic; with the former of which they give a black, and with the latter a yellowish precipitate. As lead and arsenic, however, are never found in natural waters, I shall reserve, for another occasion, what I have to say on the application of these tests.

TABLE

Showing the Substances that may be expected in Mineral Waters, and the Means of detecting them.

Acids, in general. Infusion of litmus.—Syrup of violets, I.

Acid, boracic. Acetate of lead, XIII. 3.

Acid, carbonic. Infusion of litmus, I. 1. 2.—Lime-water, VII. 1.—Barytic water, IX. 1.

Acid muriatic. Nitrate and acetite of silver, XII.

Acid, nitric. Sulphuric acid, IV. 4.

Acid, phosphoric. Solutions of barytes, XV. 2.

Acid, sulphurous. By its smell,—and destroying the colour of litmus, and of infusion of red roses: by the cessation of the smell a few hours after the addition of black oxyd of manganese.

Acid, sulphuric. Solution of pure barytes, IX. Barytic salts, XV Acetite of lead, XII.

Alkalies in general. Vegetable colours, II. Muriate of lime, XIX.

Ammonia, by its smell, and tests, II.

Barytes, and its compounds, by sulphuric acid, IV.

Carbonates in general. Effervesce on adding acids.

Earths dissolved by carbonic acid. By a precipitation on boiling,—by pure alkalies, VII.

Iron dissolved by carbonic acid. Tincture of galls, III 1. Prussiate of potash, XVI. 1. Succinate of ammonia, XVII.

Iron dissolved by sulphuric acid. Same tests, III. 3. XVI. 2. XVII.

Lime in a pure state. Water saturated with carbonic acid. Blowing air from the lungs. Oxalic acid, VI.

Lime dissolved by carbonic acid. Precipitation on boiling.—Caustic alkalies, VII. Oxalic acid, VI.

Lime dissolved by sulphuric acid. Oxalate of ammonia, VI. Barytic solutions, IX. and XV.

Magnesia dissolved by carbonic acid.—Precipitation on boiling,—the precipitate soluble in dilute sulphuric acid.

Magnesia dissolved by other acids. Precipitated by pure ammonia, not by the carbonate, VII. 5. Phosphate of soda, XVII.

Muriates of alkalies. Solutions of silver, XII.

Muriates of lime. Solutions of silver, XII. Oxalid acid, and oxalate of ammonia, VI.

Sulphates in general. Barytic solutions, IX. and XV. Acetite of lead, XIII.

Sulphate of alumine. Barytic solutions, IX. and XV.—A precipitate by carbonate of ammonia not soluble in acetous acid, but soluble in pure fixed alkalies by boiling. Succinates, XVII 2.

Sulphate of lime. Barytic solutions, IX. and XV —Oxalic acid, and oxalates, VI.—A precipitate by alkalies not soluble in dilute sulphuric acid.

Sulphurets of alkalies. Polished metals, X. Smell on adding sulphuric or muriatic acid —Nitrous acid, V.

Sulphuretted hydrogen gas. By its smell. Infusion of litmus, I. Polished metals, X. Acetite of lead, XIII. 2.

The vapour of putrefying animal or vegetable matter dissolved in water, according to Klaproth, vol. i, p. 590, often gives a deceptive indication of sulphuretted hydrogen.

Besides the remarks already offered, it may not be improper to add, for the information of our readers, the following list of re-agents, together with the necessary fluxes for the blow-pipe, which we have extracted from a publication, entitled "A description of a portable chest of chemistry; or a complete collection of chemical tests for the use of chemists, physicians, mineralogists, metallurgists, scientific artists, manufacturers, farmers, &c. by J. F. A. Gottling, of Jena, in Saxony, translated from the German,1791,12mo." This book describes more than 150 experiments, and which the young practioner should consult at the time of commencing his operations.

First Drawer.

1. Tincture of Litmus.
2. Lixivium of Prussian blue.
3. Vitriolic acid.
4. Nitrous acid.
5. Marine acid.
6. Acetous acid.
7. Mild volatile alkali.
8. Mild vegetable alkali.
9. Highly rectified spirit of wine.
10. Lime-water.
11. Distilled water.
12. Calcareous liver of sulphur.
13. Crystals of tartar in powder.

14. A phial containing a wine-test for detecting bad wines.
15. Vitriolic argilla (alum.)
16. Oil of olives.
17. Oil of linseed.
18. Oil of turpentine.
19. Ether.
20. Acid of sugar.
21. Solution of alum.
22. Oil of tartar per deliquium.
23. Salt of tartar.
24. Aqua regia for gold, two nitre and one marine.
25. Aqua regia for platina, half marine and half nitrous acid.

The three following are the most esteemed fluxes, to be used with the blowpipe.

26. Dry mineral alkali.
27. Glass of borax.
28. Glaciacal acid of phosphorus.
29. Nitre powdered.
30. Red tartar powdered.
31. White arsenic.
32. Vitriol of iron, and copper.

Second Drawer.

1. Caustic vegetable alkali.
2. Caustic volatile alkali.
3. A solution of lead in acetous acid.
4. A solution of soap.
5. A solution of arsenic.
6. A solution of corrosive sublimate in distilled water.
7. A solution of mercury in nitrious acid, prepared with heat.
8. A solution of mercury in nitrous acid, prepared without heat.
9. Volatile liver of sulphur.
10. Spirituous tincture of galls.
11. Ponderous earth dissolved in marine acid.
12. Nitrous solution of silver.
13. Nitrous solution of copper.
14. Purified sal-ammoniac.
15. Purified Epsom-salt.
16. A solution of vitriol in copper.
17. Cuprum ammoniacum.
18. Quicksilver.
19. Mineral alkali.
20. Calcined borax.
21. Fusible salt of urine.
22. Essential salt of wild sorrel.
23. Salited lime.
24. Sugar of lead.
25. Tincture of turmeric.
26. Tincture of Brazil wood.

To the preceding are added prepared papers, viz.

1. Litmus paper.
2. Brazil wood paper.
3. Turmeric paper.
4. Litmus paper reddened with vinegar.

And occasionally are packed with the same apparatus, two cylindrical glass cups, to exhibit the operations by; two or three glass mattrasses, to contain the substances with their solvents over the fire; a small glass funnel, a small porcelain pestle and mortar, one or two small crucibles, a wooden trough to wash the ground ores; some sticks of glass, and other small articles convenient in the processes.

The above constitute what has been called the humid laboratory. A blowpipe with fluxes, silver spoon, and other useful mineralogical implements, are packed into a pocket fish-skin case, and are called the dry laboratory.

In a small tract published by Mr. F. Accum, we have a catalogue of re-agents, which are selected from a number, adapted to the analysis of ores, earths, and stones, sails, mineral and native salts, and inflammable fossils, viz.

List of Chemical re-agents, or tests.

Sulphuric acid.
Nitric acid.
Muriatic acid.
Nitro-muriatic acid.
Oxygenized muriatic acid.
Phosphoric acid.
Acetous acid.
Tartareous acid.
Boracic acid.
Crystallized potash.
    soda.
    barytes.
Liquid ammonia.
Carbonate of potash.
Carbonate of soda freed from its water of crystallization.
Muriate of tin.
    platina.
    gold.
    barytes.
    mercury.
    ammonia.
Nitrate of lead.
    mercury.
    silver.
    potash.
    barytes.
Barytic water.
Sulphate of potash.
    soda.
    iron.
Alcohol.
Tincture of galls.
    turmeric
    litmus.
Prussiate of potash.
Black flux.

White flux.
Oxalate of ammonia.
Fluate of ammonia.
Acetite of silver.
Hydro-sulphuret of ammonia.
Phosphate of soda and ammonia..
Cylinders of copper.
tin.
zinc.
iron.

As a short account of the analysis of inflammable fossils and ores, may be useful to the reader, we extract the following observations from Henry's Chemisty, 8vo. p. 352.

Analysis of Inflammable Fossils.

The exact analysis of inflammable fossils is seldom necessary, in directing the most beneficial application of them. It may be proper, however, to offer a few general rules for judging of their purity.

I. *Sulphur.*

Sulphur should be entirely volatilzed by distillation, in a glass retort. If any thing remain fixed, it must be considered as an impurity, and may be examined by the preceding rules.

Sulphur, also, should be totally dissolved by boiling with solution of pure pot ash, and may be separated from its impurities by this alkali.

Impure sulphur, consumed by burning in a small crucible, leaves a residue of oxide of iron, and silex.

II. *Coals.*

1. The proportion of bituminous matter in coal, may be learnt by distillation, in an earthen retort, and collecting their product.

2. The proportion of earthy or metallic ingredients may be found, by burning the coal, with access of air, on a red-hot iron. What remains unconsumed must be considered as an impurity, and may be analized by the foregoing rules.

3. The proportion of carbon may be ascertained by observing the quantity of nitrate of potash, which a given weight of the coal is capable of decomposing.—For this purpose, let 500 grains or more, of perfectly pure nitre be melted in a crucible, and when red-hot, let the coal to be examined, reduced to a coarse powder, be projected on the nitre, by small portions at once, not exceeding one or two grains. Immediately, when the flame, occasioned by one projection, has ceased, let another be made, and so on, till the effect ceases. The proportion of carbon in the coal, is directly proportionate to the quantity required to alkalize the nitre.—Thus, since 12.709 of carbon are required to alkalize 100 of nitre, it will be easy to deduce the quantity of carbon, in a given weight of coal, from the quantity of nitre which it is capable of decomposing. This method, however, is liable to several objections, which its inventor, Mr. Kirwan, seems fully aware of. See his Elements of Mineralogy, vol. ii. p. 514.

Plumbago, or Black-lead.

Is another inflammble substance, which it may sometimes be highly useful, to be able to identify, and to judge of its purity. When projected on red-hot nitre, it should detonate; and, on dissolving the decomposed nitre, an oxide of iron should remain, amounting to one-tenth the weight of the plumbago. Any mineral, therefore, that answers to these characters, and leaves a shining trace on paper, like that of the black-lead pencils, is plumbago.

Analysis of Metallic Ores.

The class of metals comprehends so great a number of individuals, that it is almost impossible to offer a comprehensive formula, for the analysis of ores.—Ores of the same metal, also, as the mineralizing ingredients vary, require very different treatment. Yet some general directions are absolutely necessary, to enable the naturalist to judge of the composition of bodies of this class

The ores of metals may be analized in two modes, in the humid and the dry way. The first is effected with the aid of acids, and other liquid agents, and may often be accomplished by persons who are prevented, by the want of furnaces, and other necessary apparatus, from attempting the second. If sulphur, however, be present in an ore, which may be generally known by its external characters, as described by mineralogical writers, it impedes the action of acids; and should be separated, either by roasting the ore on a muffle, or by projecting it, mixed with twice or thrice its weight of nitre into a red-hot crucible, washihg off the alkali afterwards, by hot water.

It is hardly possible to employ a solvent, capable of taking up all the metals. Thus, the nitric acid does not act on gold or platina; and the nitro-muriatic, which dissolves these metals, has no solvent action on silver. It will be necessary, therefore, to vary the solvent according to the nature of the ore under examination.

1. *For Ores of Gold and Platina.*

The nitro-muriatic acid is the most proper solvent. A given weight of the ore

may be digested with this acid, as long as it extracts any thing. The solution may be evaporated to dryness, in order to expel the excess of acid, and dissolved in water. The addition of a solution of tin and muriatic acid, will shew the presence of gold by a purple precipitate; and platina will be indicated by a precipitate, on adding a solution of muriate of ammonia. When gold and platina are both contained in the same solution, they may be separated from each other, by the last mentioned solution, which throws down the platina, but not the gold. In this way platina may be detached, also, from other metals.

When gold is contained in a solution, along with several other metals, it may be separated from most of them, by adding a dilute solution of sulphate of iron. The only metals, which this salt precipitates, are gold, palladium, silver and mercury.

2. For extracting *silver* from its ores, the nitric acid is the most proper solvent. Nitric acid, however, does not act on horn-silver ore, which must be decomposed by carbonate of soda. The silver may be precipitated from nitric acid, by muriate of soda, (common salt.) Every hundred parts of the precipitate contains 75 of silver. But, as lead may be present in the solution, and this metal is also precipitated by muriate of soda, it may be proper to immerse in the solution, (which should not have any excess of acid,) a polished plate of copper. This will precipitate the silver, if present, in a metallic form. The muriate of silver is also soluble in liquid ammonia, which that of lead is not. For examples of the analysis of silver ores, the reader may consult Klaproth, i. p. 554, &c.

3. *Copper Ores* may be analized by boiling them with five times their weight, of concentrated sulphuric acid, till a dry mass is obtained, from which water will extract the sulphate of copper. This salt is to be decomposed by a polished plate of iron, immersed in a dilute solution of it. The copper will be precipitated in a metallic state, and may be scraped off and weighed.

If silver be suspected along with copper, nitrous acid must be employed as the solvent; and a plate of polished copper will detect the silver.

The reader, who engages in the analysis of copper ores, will derive much advantage from the examples to be found in Klaproths' Essays, vol. i. p. 54, 541, &c.; and also from Mr. Chenevix's paper on the analysis of arseniates of copper and iron, Phil. Trans. 1801; Nicholson's Journal, 8vo. vol. i.; or Phil. Mag.

4. *Iron ores* may be dissolved in dilute muriatic acid, or, if the metal be too highly oxydized, to be dissolved by this acid, they must be previously mixed with one-eighth of their weight of powdered charcoal, and calcined in a crucible for one hour. The iron is thus rendered soluble.

The solution must then be diluted with ten or twelve times its quantity of water, previously well boiled, to expel the air, and must be preserved in a well-stopped glass bottle for six or eight days. The phosphate of iron will, within that time, be precipitated, if any be present, and the liquor must be decanted off.

The solution may contain the oxides of iron, manganese and zinc. It may be precipitated by carbonate of soda, which will separate them all. The oxide of zinc will be taken up by a solution of pure ammonia; distilled vinegar will take up the manganese, and will leave the oxide of iron. From the weight of this, after ignition, during a quarter of an hour, 28 per cent. may be deducted. The remainder shows the quantity of iron.

5. *Tin ores*. To that most accomplished analyst, Klaproth, we owe the discovery of a simple and effectual mode of analizing tin ores in the humid way.

Boil 100 grains, in a silver vessel, with a solution of 600 grains of pure potash.—Evaporate to dryness, and then ignite, moderately, for half an hour. Add boiling water, and if any portion remain undissolved, let it undergo a similar treatment.

Saturate the alkaline solution with muriatic acid, which will throw down an oxide of tin. Let this be redissolved by an excess of muriatic acid; again precipitated by carbonate of soda; and, being dried and weighed, let it, after lixiviation, be once more dissolved in muriatic acid. The insoluble part consists of silex. Into the colourless solution, diluted with two or three parts of water, put a stick of zinc, round which the reduced tin will collect. Scrape off the deposit, wash, dry, and fuse it under a cover of tallow in a capsule placed on charcoal. A button of pure metallic tin will remain at the bottom, the weight of which, deducted from that of the ore, indicates the proportion of oxygen.

The presence of tin in an ore is indicated by a purple precipitate, on mixing its solutoin in muriatic acid with one of gold in nitro-muriatic acid.

6. *Lead ores* may be analyzed by solution in nitric acid, diluted with an equal weight of water. The sulphur, if any, will remain undissolved. Let the solution be precipitated by carbonate of soda. If

any silver be present, it will be taken up by pure liquid ammonia. Wash off the excess of ammonia by distilled water; and add concentrated, sulphuric acid, applying heat, so that the muriatic acid may be wholly expelled. Weigh the sulphate of lead, and, after deducting 70 per cent. the remainder shows the quantity of lead.

Muriate of lead may also be separated from muriate of silver by its greater solubility in warm water. From the solution, iron may be separated by prussiate of potash, and the solution decomposed by sulphuric acid.

7. *Mercury* may be detected in ores that are supposed to contain it, by distillation in an earthen retort with half their weight of iron filings or lime. The mercury, if any be present, will rise and be condensed in the receiver.

8. *Ores of Zinc* may be digested with the nitric acid, and the part that is dissolved boiled to dryness, again dissolved in the acid, and again evaporated. By this means the iron, if any be present, will be rendered insoluble in dilute nitric acid, which will take up the oxide of zinc. To this solution add pure liquid ammonia, in excess, which will separate the lead and iron, if any should have been dissolved; and the excess of alkali will retain the oxide of zinc. This may be separated by the addition of an acid.

9. *Antimonial ores.* Dissolve a given weight, in three or four parts of muriatic and one of nitric acid. This will take up the antimony, and leave the sulphur, if any. On dilution with water, the oxide of antimony is precipitated, and the iron and mercury remain dissolved. Lead may be detected by sulphuric acid. See Klaproth on the Analysis of Antimoniated Silver Ore, I, p. 560.

10. *Ores of arsenic* may be digested with nitro-muriatic acid, composed of one part nitric, and one and a half or two of muriatic acids. Evaporate the solution to one fourth, and add water, which will precipitate the arsenic. The iron may afterwards be separated by ammonia. See Chenevix, Phil. Trans. 1801, p. 215.

11. *Ores of bismuth* are also assayed by digestion in nitric acid moderately diluted. The addition of water precipitates the oxide, and, if not wholly separated at first, evaporate the solution; after which, a farther addition of water will precipitate the remainder. See Analysis of an Ore of Bismuth and Silver, in Klaproth, I, p. 554. Mode of detecting a small Quantity of Silver in Bismuth, ditto, p. 220, c.

12. *Ores of cobalt* may be dissolved in nitro-muriatic acid. Then add carbonate of potash, which, at first, separates iron and arsenic. Filter, and add a farther quantity of the carbonate, when a greyish red precipitate will fall down, which is oxide of cobalt. The iron and arsenic may be separated by heat, which volatilizes the arsenic. Cobalt is also ascertained, if the solution of an ore in muriatic acid gives a sympathetic ink. See Chap. xix, sect 18. An example of the analysis of an ore of cobalt may be seen in Klaproth, I, p. 564, and sulphate of cobalt, p. 579.

13. *Ores of nickel.* Dissolve them in nitric acid, and add to the solution pure ammonia, in such proportion that the alkali may be considerably in excess. This will precipitate other metals, and will retain the oxide of nickel in solution, which may be obtained by evaporation to dryness, and heating the dry mass till the nitrate of ammonia has sublimed.

14. *Ores of manganese.* The earths, and several of the metals, contained in these ores, may first be separated by diluted nitric acid, which does not act on highly oxydized manganese. The ore may afterward be digested with strong muriatic acid, which will take up the oxide of manganese. Oxygenized muriatic acid will arise, if a gentle heat be applied, and may be known by its peculiar smell, and by its discharging the colour of wet litmus paper exposed to the fumes. From muriatic acid the manganese is precipitated by carbonate of soda, in the form of a white oxide, which becomes black when heated in a crucible. Ores, suspected to contain manganese, may also be distilled *per se*, or with sulphuric acid, when oxygen gas will be obtained. Oxide of manganese may be separated from oxide of iron by solution of pure potash, which takes up the former but not the latter. See the analysis of an ore of manganese, *via humida*, in Klaproth, I, p. 510; and of a cobaltic ore of manganese, p. 569.

Ores of manganese may also be distinguished by the colour they impart to borax, when exposed together to the blowpipe.

15. *Ores of Uranium.* These may be dissolved in dilute nitric acid, which takes up the uranitic oxide, and leaves that of iron; or in dilute sulphuric acid, which makes the same election; or, if any iron has got into the solution, it may be precipitated by zinc. Then add caustic potash, which throws down the oxide of zinc and uranium. The former may be separated by digestion in pure ammonia, which leaves, undissolved, the oxide of

uranium. This, when dissolved by dilute sulphuric acid, affords, on evaporation, crystals of a lemon-yellow colour.

If copper be present, it will be dissolved, along with the zinc, by the ammonia. If lead, it will form, with sulphuric acid, a salt much less soluble than the sulphate of uranium, and which, on evaporation, will therefore separate first.

16. *Ores of tungsten.* For these the most proper treatment seems to be digestion in nitro-muriatic acid, which takes up the earths and other metals. The tungsten remains in the form of a yellow oxide, distinguishable, by its becoming white on the addition of liquid ammonia, from the oxide of uranium. To reduce this oxide to tungsten, mix it with an equal weight of dried blood, heat the mixture to redness, press it into another crucible, which should be nearly full, and apply a violent heat for an hour at least.

17. *Ores of molybdena.* Repeated distillation to dryness, with nitric acid, converts the oxide into an acid, which is insoluble in nitric acid, and may be thus separated from other metals, except iron, which may be dissolved by sulphuric or muriatic acids. The solution in sulphuric acid is blue, when cold, but colourless, when heated. That in muriatic acid is only blue when the acid is heated and concentrated. (See Hatchett's Analysis of the Carinthian Molybdate of Lead, Phil. Trans. 1796; and Klaproth, vol. I, p. 534. 538.)

Respecting the ores of the remaining metals, sufficient information has been already given; and they are of such rare occurrence, that it is unnecessary for us to describe them in this place. It may be proper, however, to state where the best examples of the analysis of each may be found.

18. *Ores of titanium.* Consult Gregor, in Journ. de Physique, xxxix. 72. 152; Klaproth, I. 496; and Chenevix, Nich. Journ. V. 132.

19. *Ores of tellurium.* See Klaproth, II, 1.

20. *Ores of tantalium.* Ann. de Chim. xliii. 276.

21. *Ores of chromium.* Vauquelin, Ann. de Chim. xxv.

22. *Ores of columbium.* Hatchett, Phil. Trans. 1802.

23. *Ores of palladium and rhodium.* Wollaston, Phil. Trans. 1805.

24. *Ores of iridium aud osmium.* Tennant, Phil. Trans. 1804.

25. *Ores of cerium.* Hisenger and Berzelius, and Vauquelin, Nich. Journ. xii.

Besides the information given in the preceding pages, we might enumerate the application of these and other reagents, to the purposes of the physician, artist, manufacturer, farmer and the domestic economist. We have already mentioned their use in the discovery of poisons. See POISONS. And have also, on several occasions, given their miscellaneous uses. We will add, however, the following article, which we have taken from the same excellent work, for which we were originally indebted for its arrangement, to Goetling a celebrated German professor.

RULES FOR ASCERTAINING THE PURITY OF CHEMICAL PREPARATIONS, EMPLOYED FOR THE PURPOSES OF MEDICINE, AND FOR OTHER USES.

1. *Sulphuric acid—Acidum Vitriolicum of the London Pharmacopœia—Oil of Vitriol.*

The specific gravity of sulphuric acid should be 1850. It should remain perfectly transparent when diluted with distilled water. If a sediment occur, on dilution, it is a proof of the presence of sulphate of lead or of lime.

Iron may be detected in sulphuric acid, by saturating a diluted portion of it with pure carbonate of soda, and adding prussiate of potash, which will manifest the presence of iron by a prussian blue precipitate; or it will be discovered by a purplish or blackish tinge, on the addition of tincture of galls to a similarly saturated portion. Copper may be discovered, by pouring, into a similarly saturated solution, pure solution of ammonia; and lead may be detected by the sulphuret of ammonia. The latter metal, however, is generally precipitated, on dilution, in combination with sulphuric acid.

Sulphate of potash or of soda may be found by saturating the diluted acid with ammonia, evaporating to dryness, and applying a pretty strong heat. The sulphate of ammonia will escape, and that of potash or of soda will remain, and may be distinguished by its solubility and other characters.

2. *Nitric and Nitrous Acids.—Acidum Nitrosum, Pharm. Lond.—Aqua Fortis.*

The nitric acid should be perfectly colourless, and as limpid as water. It should be preserved in a dark place, to prevent its conversion into the nitrous kind.

These acids are most likely to be adulterated with sulphuric and muriatic acids. The sulphuric acid may be discovered by adding to a portion of the acid, largely

diluted, nitrated or muriated barytes, which will occasion, with sulphuric acid, a white and insoluble precipitate. The muriatic acid may be ascertained by nitrate of silver, which affords a sediment, at first white, but which becomes coloured by exposure to the direct light of the sun. Both these acids, however, may be present at once; and, in this case, it will be necessary to add a solution of nitrate of barytes, as long as any precipitate falls, which will separate the sulphuric acid. Let the sediment subside, decant the clear liquor, and add the nitrate of silver. If a precipitate appear, muriatic acid may be inferred to be present also. Muriatic acid may, also, be detected by adding a solution of sulphate of silver.

These acids should have the specific gravity of 1550.

3. *Muriatic Acid—Acidum Muriaticum, P. L.—Spirit of Salt.*

This acid generally contains iron, which may be known by its yellow colour; the pure acid being perfectly colourless. It may also be detected by the same mode as was recommended in examining sulphuric acid.

Sulphuric acid is discoverable by a precipitation, on adding to a portion of the acid, diluted with five or six parts of pure water, a solution of the muriate of barytes.

The specific gravity of this acid should be at least 1170.

4. *Acetic Acid—Acidum Acetosum, P. L. —Radical or concentrated Vinegar.*

This acid is often contaminated by sulphurous and sulphuric acid. The first may be known by drawing a little of the vapour into the lungs, when, if the acid be pure, no unpleasant sensation will be felt; but, if sulphurous acid be contained in the acetic, it will not fail to be discovered in this mode. The sulphuric acid is detected by muriated barytes; copper, by supersaturation with pure ammonia; and lead, by sulphuret of ammonia.

The specific gravity of this acid should be 1060 at least.

5. *Acetous Acid—Acetum Distillatum, P. L.—Distilled Vinegar.*

If vinegar be distilled in copper vessels, it can hardly fail being contaminated by that metal; and, if a leaden worm be used for its condensation, some portion of lead will certainly be dissolved. The former metal will appear on adding an excess of solution of pure ammonia; and lead will be detected by the sulphuretted ammonia, or by water saturated with sulphuretted hydrogen.

It is not unusual, in order to increase the acid taste of vinegar, to add sulphuric acid. This acid may be immediately discovered by solutions of barytes, which, when vinegar has been thus adulterated, throw down a white precipitate.

6. *Boracic Acid—Sedative Salt of Homberg.*

Genuine boracic acid should totally dissolve in five times its weight of boiling alcohol: and the solution, when set on fire, should emit a green flame. The best boracic acid forms small hexangular scaly crystals of a shining silvery white colour. Its specific gravity is 1480.

7. *Tartarous Acid.*

This acid contains sulphuric acid; to discover which, let a portion be dissolved in water, and a solution of acetite of lead be added. A precipitate will appear, which, if the acid be pure, is entirely redissolved by a few drops of pure nitric acid, or by a little pure acetic acid. If any portion remain undissolved sulphuric acid is the cause. Muriate of barytes, also, when the acid is adulterated with sulphuric acid, but not otherwise, gives a precipitate insoluble by an excess of muriatic acid.

8. *Acid of Amber.*

Acid of amber is adulterated, sometimes with sulphuric acid and its combinations; sometimes with tartarous acid; and at others with muriate of ammonia.

Sulphuric acid is detected by solutions of barytes; tartarous acid by carbonate of potash, which forms a difficultly soluble tartrite; and muriate of ammonia by nitrate of silver, which discovers the acid, and by a solution of pure potash, which excites a strong smell of ammonia.

Pure acid of amber is a crystalline white salt of an acid taste, soluble in twenty-four parts of cold, or eight of hot water, and is volatilized, when laid on red-hot iron, without leaving any ashes or other residue.

9. *Acid of Benzoin—Flores Benzoes, P. L.*

This acid is not very liable to adulteration. The best has a brilliant white colour and a peculiarly grateful smell. It is soluble in a large quantity of boiling water or alcohol, and leaves no residue when placed on a heated iron.

10. *Sub-carbonate of Potash—Kali Preparatum, P. L.*

The salt of tartar of the shops gene-

rally contains sulphate and muriate of potash, and siliceous and calcareous earths. It should dissolve entirely, if pure, in twice its weight of cold water; and any thing that remains undissolved may be regarded as an impurity. Sometimes one fourth of foreign mixtures may thus be detected, the greater part of which is sulphate of potash. To ascertain the nature of the adulteration, dissolve a portion in pure and diluted nitric acid: the siliceous earth only will remain undissolved. Add, to one portion of the solution, nitrate of barytes; this will detect sulphate of potash by a copious precipitate. To another portion add nitrate of silver, which will discover muriatic salts; and, to a third, oxalate or fluate of ammonia, which will detect calcareous earth.

The solution of carbonate of potash (*Aqua Kali, P. L.*) may be examined in a similar manner.

11. *Solution of pure Potash—Aqua Kali Puri, P. L.*

This may be assayed, for sulphuric and muriatic salts, by saturation with nitric acid, and by the tests recommended in speaking of carbonate of potash. A perfectly pure solution of potash should remain transparent on the addition of barytic water. If a precipitate should ensue, which dissolves with effervescence in dilute muriatic acid, it is owing to the presence of carbonic acid: if the precipitate is not soluble, it indicates sulphuric acid. A redundancy of carbonic acid is also shown by an effervescence, on adding diluted sulphuric acid, and an excess of lime by a white precipitate, on blowing air from the lungs, through the solution, by means of a tobacco-pipe, or a glass tube.

The solution should be of such a strength, as that an exact wine-pint may weigh 18 ounces troy.

12. *Carbonate of Soda—Natron Preparatum, P. L.*

Carbonate of soda is scarcely ever found free from muriate and sulphate of soda. These may be discovered by adding, to a little of the carbonate saturated with pure nitric acid, first nitrate of barytes, to detect sulphuric acid, and afterwards nitrate of silver, to ascertain the presence of muriatic acid. Carbonate of potash will be shown by a precipitate ensuing on the addition of tartarous acid to a strong solution of the alkali; for, this acid forms a difficultly soluble salt with potash, but not with soda.

13. *Solution of Carbonate of Ammonia—Aqua Ammoniæ, P. L.*

This should have the specific gravity of 1150; should effervesce on the addition of acids; and should afford a strong coagulum on adding alcohol.

14. *Carbonate of Ammonia—Ammonia Preparata, P. L.*

This salt should be entirely volatilized by heat. If any thing remain, when it is laid on a heated iron, carbonate of potash or of lime may be suspected; and these impurities are most likely to be present if the carbonate of ammonia be purchased in the form of a powder. It should therefore always be bought in solid lumps. Sulphuric and muriatic salts, lime and iron, may be discovered by adding to the alkali, saturated with nitric acid, the appropriate tests already often mentioned.

15. *Solution of pure Ammonia in Water—Aqua Ammoniæ Puræ, P. L.—Strong Spirit of Sal Ammoniac.*

The volatile alkali, in its purest state, exists as a gas condensible by water, and is the only form under which it is applicable to useful purposes. This solution should contain nothing besides the volatile alkali; the alkali should be perfectly free from carbonic acid, and should be combined with water in the greatest possible proportion. The presence of other salts may be discovered by saturating a portion of the solution with pure nitric acid, and adding the tests for sulphuric and muriatic acids. Carbonic acid is shown by a precipitation on mixing the solution with one of muriate of lime; for this earthy salt is not precipitated by pure ammonia. The only mode of determining the strength of the solution is by taking its specific gravity, which, at 60° Fahrenheit, should be as 905, or thereabouts, to 1000.

16. *Spirit of Hartshorn—Liquor Volatilis Cornu Cervi, P. L.*

This may be counterfeited by mixing the aqua ammoniæ puræ with the distilled spirit of hartshorn, in order to increase the pungency of its smell, and to enable it to bear an addition of water. The fraud is detected by adding alcohol to the sophisticated spirit; for, if no considerable coagulation ensues, the adulteration is proved. It may also be discovered by the usual effervescence not ensuing with acids. The solution should have the specific gravity of 1500.

17. *Sulphate of Soda—Natron Vitriolatum; P. L.—Glauber's Salt.*

This salt ought not to contain an excess of either acid or alkali, both of which may be detected by the vegetable infusions. Nor should it be mixed with earthy or metallic salts; the former of which are detected by carbonate, and the latter by prussiate of potash. Muriate of soda is discovered by adding nitrate of barytes till the precipitate ceases, and afterwards nitrate of silver, or more simply by a solution of sulphate of silver. Sulphate of potash is discovered by its more sparing solubility. The sulphate of soda, however, being itself one of the cheapest salts, there is little risk of its being intentionally sophisticated.

18. *Sulphate of Potash—Kali Vitriolatum, P. L.—Vitriolated Tartar.*

The purity of this salt may be ascertained by the same means as that of the former one. The little value of this salt renders it pretty secure from wilful adulteration.

19. *Nitrate of Potash—Nitrum Purificatum, P. L.—Nitre or Salt Petre.*

Nitrate of potash is, with great difficulty, freed entirely from muriate of soda; and a small portion of the latter, except for nice chemical purposes, is an admixture of little importance. To discover muriate of soda, a solution of nitrate of silver must be added as long as any sediment is produced. The precipitate, washed and dried, must be weighed. Every hundred grains will denote 42½ of muriate of soda.

Sulphate of potash or soda may be discovered by nitrate or muriate of barytes.

20. *Muriate of Soda.---Common Salt.*

Common salt is scarcely ever found free from salts with earthy bases, chiefly muriates of magnesia and lime, which are contained in the brine, and adhere to the crystals. The earths may be precipitated by carbonate of soda, and the precipitated lime and magnesia may be separated from each other.

21. *Muriate of Ammonia—Ammonia Muriata, P. L.—Sal Ammoniac.*

This salt ought to be entirely volatilized, by a low heat, when laid on a heated iron. It sometimes contains sulphate of ammonia, however, which being also volatile, cannot be thus detected. To ascertain the presence of the latter salt, add the muriate or nitrate of barytes, which will indicate the sulphate by a copious and insoluble precipitate.

22. *Acetate of Potash—Kali Acetatum, P. L.*

Genuine acetate of potash is perfectly soluble in four times its weight of alcohol, and may thus be separated from other salts that are insoluble in alcohol. The tartrite of potash (soluble tartar) is the adulteration most likely to be employed. This may be discovered by adding a solution of tartareous acid, which, if the suspected salt be present, will occasion a copious precipitate. The tartrite is also detected by its forming a precipitate with acetate of lead, or muriate of barytes, soluble in acetic or muriatic acid; and sulphates by a precipitate with the same agents, insoluble in acids.

23. *Neutral Tartrite of Potash—Kali Tartarizatum, P. L.—Soluble Tartar.*

This salt should afford a very copious precipitate on adding tartareous acid.—The only salt likely to be mixed with it is sulphate of soda, which may be detected by a precipitate with muriated barytes, insoluble in diluted muriatic acid.

24. *Acidulous Tartrite of Potash.—Tartarum Purificatum, P. L.—Cream of Tartar.*

The only substance with which this salt is likely to be adulterated is sulphate of potash. To determine whether this be present, pour on about half an ounce of the powdered crystals, two or three ounce measures of distilled water; shake the mixture frequently, and let it stand one or two hours. The sulphate of potash, being more soluble than the tartrite, will be taken up; and may be known by the bitter taste of the solution, and by a precipitate, on adding muriate of barytes, which will be insoluble in muriatic acid.

25. *Compound Tartrite of Soda and Potash—Natron Tartarizatum, P. L.—Rochelle or Seignette's Salt.*

Sulphate of soda, the only salt with which this may be expected to be adulterated, is discovered by adding to a solution of Rochelle salt, the acetite of lead or muriate of barytes. The former, if the sulphate be present, affords a precipitate insoluble in acetous acid, and the latter one, insoluble in muriatic acid.

26. *Sulphate of Magnesia—Magnesia Vitriolata, P. L.—Epsom Salt.*

This salt is very likely to be adulterated with sulphate of soda, or Glauber's salt, which may be made to resemble the magnesian salt in appearance, by stirring it briskly at the moment it is about to

crystallize. The fraud may be discovered very readily, if the salt consists entirely of the sulphate of soda, because no precipitation will ensue on adding carbonate of potash. If only a part of the sulphate of soda, detection is not so easy, but may still be accomplished. For, since 100 parts of pure sulphate of magnesia, give between 30 and 40 of the dry carbonate, when completely decomposed by carbonate of potash, if the salt under examination afford a considerably less proportion, its sophistication may be fairly inferred: or, to discover the sulphate of soda, precipitate all the magnesia, by pure ammonia, with the aid of heat. Decant the clear liquor from the precipitate, filter it, and, after evaporation to dryness, apply such a heat, as will volatilize the sulphate of ammonia, when that of soda will remain fixed.

Muriate of manganese or of lime, may be detected by the salt becoming moist, when exposed to the air, and by a precipitation with nitrated silver, after nitrate of barytes has separated all the sulphuric acid and magnesia. Lime is discoverable by oxalic acid.

27. *Sulphate of Alumine—Alum.*

Perfectly pure alum, should contain neither iron or copper. The former is manifested by adding, to a solution of alum, prussiate of potash, and the latter by an excess of pure ammonia.

28. *Borate of Soda—Borax.*

Borate of soda, if adulterated at all, will probably be so with alum, or fused muriate of soda. To discover these, borax must be dissolved in water, and its excess of alkali be saturated with nitric acid. Nitrate of barytes, added to this saturated solution, will detect the sulphuric salt, and nitrate of silver the muriate of soda.

29. *Sulphate of Iron—Ferrum Vitriolatum, P. L.—Green Vitriol.*

If this salt should contain copper, which is the only admixture likely to be found in it, pure ammonia, added till a precipitation ceases, will afford a blue liquor. Any copper that may chance to be present, may be separated, and the salt purified, by immersing in a solution of it, a clear polished plate of iron.

30. *Tartarized Antimony—Antimonium Tartarizatum, P. L.—Emetic Tartar.*

A solution of this salt should afford, with acetate of lead, a precipitate perfectly soluble in dilute nitric acid. A few drops of the sulphuret of ammonia, also, should immediately precipitate a gold-coloured sulphuret of ammonia.

31. *Muriate of Mercury—Hydrargyrus Muriatus, P. L.—Corrosive Sublimate.*

If tthere be any reason to suspect arsenic in this salt the fraud may be discovered as follows: Dissolve a small quantity of the sublimate, in distilled water; add a solution of carbonate of ammonia, till the precipitate ceases, and filter the solution. If, on the addition of a few drops of ammoniated copper, (prepared by digesting a little verdegris in the solution of pure ammonia,) to this solution, a precipitate of a yellowish green colour, is produced, the sublimate contains arsenic.

32. *Sub-muriate of Mercury—Calomel, P. L.*

Calomel should be completely saturated with mercury. This may be ascertained by boiling, for a few minutes, one part of calomel with one-thirty-second part of muriate of ammonia, (sal ammoniac) in ten parts of distilled water. When carbonate of potash is added to the filtered solution, no precipitation will ensuse, if the calomel be pure. This preparation, when rubbed in an earthen mortar with pure ammonia, should become intensely black, and should exhibit nothing of an orange hue.

33. *Mercury, or Quicksilver—Hydrargyrus P. L.*

Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses of dissolving completely some of the baser metals. This union is so strong that they even rise along with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing and becoming covered with a coat of oxide on long exposure to the air; by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxydize that metal. Pour off the water, and digest the mercury with a little acetous acid. This will dissolve the oxide of lead, which will be indicated by a blackish precipitate with sulphuretted water. Or, to this acetous solution, add a little sulphate of soda, which will precipitate a sulphate of lead, containing, when dry, 72 per cent. of me-

tal. If only a very minute quantity of lead be present, in a large quantity of mercury, it may be detected by solution in nitric acid and the addition of sulphuretted water. A dark brown precipitate will ensue, and will subside if allowed to stand a few days. One part of lead may thus be separated from 15-63 parts of mercury. (See Mr. Accum's valuable papers on the detection of adulterations, in Nicholson's Journal, 4to.) Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear if this metal be present. Tin is manifested, in like manner, by a weak solution of nitro-muriate of gold, which throws down a purple sediment, and zinc by exposing the metal to heat.

34. *Red Oxide of Mercury—Hydrargyrus Calcinatus, P. L.*

This substance is rarely found adulterated, as it would be difficult to find a substance well suited to this purpose. If well prepared, it may be totally volatilized by heat.

35. *Red Oxide of Mercury by Nitric Acid—Hydrargyrus Nitratus Ruber, P. L.—Red Precipitate*

This is very liable to adulteration with minium, or red lead. The fraud may be discovered by digesting it in acetic acid, and adding to the solution sulphuretted water, or sulphuret of ammonia, which produce, with the compounds of lead, a dirty dark coloured precipitate. It should also be totally volatilizable by heat.

36. *White Oxide of Mercury—Calx Hydrargyri Alba, P. L.—White Precipitate.*

White lead is the most probable adulteration of this substance, and chalk may also be occasionally mixed with it. The oxide of lead may be discovered as in the last article; and chalk, by adding to the dilute solution a little oxalic acid.

37. *Red Sulphuretted Oxide of Mercury—Hydrargyrus Sulphuratus Ruber, P. L.—Factitious Cinnabar.*

This substance is frequently adulterated with red lead, which may be detected by the foregoing rules. Chalk and dragon's blood are also sometimes mixed with it. The chalk is discovered by an effervescence on adding acetic acid, and by pouring oxalic acid into the acetous solution. Dragon's blood will be left unvolatilized when the sulphuret is exposed to heat, and may be detected by its giving a colour to alcohol, when the cinnabar is digested with it.

38. *Black Sulphuretted Oxide of Mercury—Hydrargyrus cum Sulphure, P. L.—Ethiops Mineral.*

The mercury and sulphur, in this preparation, should be so intimately combined, that no globules of the metals can be discovered by a magnifier; and that, when rubbed on gold, no white stain may be communicated. The admixture of ivory black may be detected by its not being wholly volatilized by heat; or, by boiling with alkali to extract the sulphur, and afterwards exposing the residuum to heat, which ought entirely to evaporate.

39. *Yellow Oxide or Sub-Sulphate of Mercury—Hydrargyrus Vitriolatus, P. L.—Turbith Mineral.*

This preparation should be wholly evaporable; and, when digested with distilled water, the water ought not to take up any sulphuric acid, which will be discovered by muriate of barytes.

40. *Fused Nitrate of Silver—Argentum Nitratum, P. L.—Lunar Caustic.*

The most probable admixture with this substance is nitrate of copper, derived from the employment of an impure silver. In moderate proportion this is of little importance. It may be ascertained by solution in water, and adding an excess of pure ammonia, which will detect copper by a deep blue colour.

41. *White Oxide of Zinc—Zincum Calcinatum, P. L.—Flowers of Zinc.*

Oxide of zinc may be adulterated with chalk, which is discoverable by an effervescence with acetous acid, and by the precipitation of this solution with oxalic acid. Lead is detected by adding, to the acetous solution, sulphuretted water, or sulphuret of ammonia. Arsenic, to which the activity of this medicine has been sometimes ascribed, is detected, also, by sulphuretted water, added to the acetous solution; but in this case the precipitate has a yellow colour, and, when laid on red hot charcoal, gives first a smell of sulphur, and afterwards of arsenic.

42. *White Oxide of Lead—Cerussa, P. L. White Lead.*

This is frequently sophisticated with chalk; the presence of which may be detected by cold acetous acid, and by adding, to this solution, oxalic acid. Carbonate of barytes is detected by sulphate of soda added to the same solution, very

largely diluted with distilled water; and sulphate of barytes, or sulphate of lead, by the insolubility of the ceruse in boiling distilled vinegar.

43. *Acetate of Lead—Cerusa Acetata, P. L.—Sugar of Lead.*

If the acetate of lead should be adulterated with acetate of lime or of barytes, the former may be detected by adding, to a dilute solution, the oxalic acid; and the latter by sulphuric acid, or solution of sulphate of soda, added to a solution very largely diluted with water. Acetate of lead ought to dissolve entirely in water, and any thing that resists solution may be regarded as an impurity.

44. *Green Oxide or Sub-acetate of Copper. Verdigris.*

This substance is scarcely ever found pure, being mixed with pieces of copper, grape-stalks, and other impurities. The amount of this admixture of insoluble substances may be ascertained by boiling a portion of verdigris with 12 or 14 times its weight of distilled vinegar, allowing the undissolved part to settle, and ascertaining its amount. Sulphate of copper may be detected by boiling the verdigris with water, and evaporating the solution. Crystals of acetite of copper will first separate, and, when the solution has been farther concentrated, the sulphate of copper will crystallize. Or, it may be discovered by adding to the watery solution muriate of barytes, which will throw down a very abundant precipitate. Tartrite of copper, another adulteration sometimes met with, is discovered by dissolving a little of the verdigris in acetous acid, and adding acetite or muriate of barytes, which will afford, with the tartarous acid, a precipitate soluble in muriatic acid.

45. *Crystallized Acetate of Copper—Distilled or Crystallized Verdigris.*

This is prepared by dissolving the common verdigris in distilled vinegar, and crystallizing the solution. These crystals should dissolve entirely in six times their weight of boiling water, and the solution should give no precipitation with solutions of barytes; for, if these solutions throw down a precipitate, sulphate of copper is indicated. This impurity, which I have frequently met with, may be discovered by evaporating the solution very low, and separating the crystals of acetate of copper. Farther evaporation and cooling will crystallize the sulphate, if any be present.

46. *Carbonate of Magnesia—Magnesia Alba, P. L.*

Carbonate of magnesia is most liable to adulteration with chalk; and, as lime forms with sulphuric acid a very insoluble salt, and magnesia one very readily dissolved, this acid may be employed in detecting the fraud. To a suspected portion of magnesia add a little sulphuric acid, diluted with 8 or 10 times its weight of water. If the magnesia should entirely be taken up, and the solution should remain transparent, it may be pronounced pure, but not otherwise. Another mode of discovering the deception is as follows: Saturate a portion of the suspected magnesia with muriatic acid, and add a solution of carbonate of ammonia. If any lime be present, it will form an insoluble precipitate, but the magnesia will remain in solution.

47. *Pure Magnesia—Magnesia Usta, P. L.—Calcined Magnesia.*

Calcined magnesia may be assayed by the same tests as the carbonate. It ought not to effervesce at all with dilute sulphuric acid; and, if the earth and acid be put together into one scale of a balance, no diminution of weight should ensue on mixing them together. It should be perfectly free from taste, and, when digested with distilled water, the filtered liquor should manifest no property of lime-water. Calcined magnesia, however, is very seldom so pure as to be totally dissolved by diluted sulphuric acid; for a small insoluble residue generally remains, consisting chiefly of siliceous earth, derived from the alkali. The solution in sulphuric acid, when largely diluted, ought not to afford any precipitation with oxalate of ammonia.

48. *Spirit of Wine, Alcohol, and Æthers.*

The only decisive mode of ascertaining the purity of spirit of wine and of æthers, is by determining their specific gravity. Highly rectified alcohol should have the specific gravity of 820 to 1000. Common spirit of wine 837. Sulphuric æther 739. The spiritus ætherius vitriolicus, P. L., or sweet spirit of vitriol, about 753, and nitric æther, the spiritus ætherius nitrosus, or sweet spirit of nitre, 908. The æthers ought not to redden the colour of litmus, nor ought those formed from sulphuric acid to give any precipitation with solutions of barytes.

49. *Essential, or Volatile Oil.*

As essential oils constitute only a very small proportion of the vegetables from which they are obtained, and bear generally a very high price, there is a consi-

derable temptation to adulterate them. They are found sophisticated, either with cheaper volatile oils, with fixed oils, or with the spirit of wine The fixed oils are discovered by distillation with a very gentle heat, which elevates the essentiai oils, and leaves the fixed ones. These last may, also, be detected by moistening a little writing paper with the suspected oil, and holding it before the fire. If the oil be entirely essential, no stain will remain on the paper. Alcohol, also, detects the fixed oils, because it only dissolves the essential ones, and the mixture becomes milky. The presence of cheaper essential oils is discovered by the smell. Alcohol, a cheaper liquid than some of the most costly essential oils, is discovered by adding water, which, if alcohol be present, occasions a milkiness.

TESTS, OR CUPELS, in assaying. See ASSAYING.

TESTS, *Manufacture of.*

The preparation of re-agents may be noticed in a general manner. Although the formation of a number of articles, which are used for the purpose of chemical investigation, has been noticed in different parts of our work, yet we shall enumerate them, and treat of such in this place, whose preparation has not been heretofore mentioned.

1. *Infusion of Litmus.*

This preparation is made as before noticed, namely, by steeping litmus, first bruised in a mortar, and tied up in a thin rag, in distilled water.

2. *Syrup of Violets.*

Is prepared by making a decoction of the violets, adding white sugar, and boiling it down to a syrup. As sold in the shops, it is mostly impure : directions for discovering its sophistication, may be found in the article, on the use of re agents.

3. *Litmus Paper.* See TESTS.

4. *Litmus Paper, or the infusion, reddened by an acid.*

This operation is performed, on the paper, by immersing it in a weak acid, the phosphoric diluted, is generally preferred; or by adding to the infusion, a portion of acid until the colour is sufficiently changed.

A drop of sulphuric acid put into a half pint of water, or common vinegar alone, may be employed.

5. *Tincture of Turmeric, of Brazil-wood, or of Rhubarb.*

May be made by digesting the material, previously bruised, in a mixture of equal parts of alcohol and water ; afterwards filtering the fluid.

6. *Turmeric, Hazel-wood, or Rhubarb Paper.*

Is prepared by staining unsized paper with the tincture, or infusion of these substances.

7. *Gallic Acid.* See GALLIC ACID.

8. *Tincture of Galls.*

Is prefered to the gallic acid as a test : it is prepared by digesting the bruised galls in alcohol, or in common spirit, and afterwards filtering the liquor.

9. *Sulphuric Acid.* See SULPHURIC ACID.

As the acid should be pure when used as a test, directions are given for that purpose, in the article on its manufacture; and to determine its purity, if purchased out of the stores, see the *uses of tests*, under the head of test.

10. *Nitric Acid.* See NITRIC ACID.

11. *Oxalic Acid.* It may be obtained, readily and economically from sugar in the following way : to six ounces of nitric acid in a stoppered retort, to which a large receiver is luted, add by degrees one ounce of lump sugar, coarsely powdered. A gentle heat may be applied during the solution, and nitric oxide will be evolved in abundance. When the whole of the sugar is dissolved, distil off a part of the acid, till what remains in the retort has a sirupy consistence, and this will form regular crystals, amounting to 58 parts from 100 of sugar. These crystals must be dissolved in water, re-crystallized, and dried on blotting paper.

12. *Oxalate of Potash.*

May be formed by saturating oxalic acid dissolved in water with pure potash ; or by saturating the excess of acid in salt of sorrel with potash.

13. *Super-Oxalate of Potash.*

Is the salt of sorrel, which may be obtained in a crystallized state, by evaporating the juice of that plant ; or by supersaturating potash with oxalic acid.

14. *Oxalate of Ammonia,*

Is made by saturating oxalic acid, with

ammonia or pure volatile alkali. For this purpose, the oxalic acid may be saturated with the carbonate of ammonia, which is known when the effervescence ceases.

15. *Oxalate of Soda,*
May be made by saturating the acid with soda, or its carbonate in a similar manner.

16 *Fluate of Ammonia,*

May be formed by adding carbonate of ammonia, to diluted fluoric acid in a leaden vessel, observing that there be a small excess of acid. The fluoric acid is formed, by distilling two parts of fluor spar, and one of oil of vitriol; the gas comes over and may be condensed.

17. *Pure Ammonia* (*aqua ammoniæ puræ.*)

Is a solution of ammoniacal gas in water, made by receiving the gas disengaged from two parts of sal ammoniac, and one of quicksilver, previously placed in a retort and heated, in a vessel containing distilled water. It is the caustic spirit of sal ammoniac of the shops.

18. *Pure Potash.* See POTASH
This alkali is obtained in a state of purity, by depriving the common potash of carbonic acid by means of lime, and then evaporating the alkaline solution to dryness, and dissolving it in alcohol. The solution in alcohol is then evaporated to dryness. If caustic potash be dissolved in alcohol, and treated in the same manner, the same preparation will be formed. For more minute directions, See POTASH.

19. *Pure Soda,*
May be formed in the same manner.

20. *Carbonate of Ammonia.*
This salt may be made by saturating the liquid ammonia with carbonic acid: it is the sal. volat. ammonia of the shops. This last, however, contains a variable quantity of carbonic acid.

21. *Carbonate of Potash.*
This salt may be prepared by saturating the pure alkali with carbonic acid, in a Nooth's machine: the sub carbonate, is the salt of tartar of the shops.

22. *Carbonate of Soda,*
May be prepared in the same manner. The carbonate of the shops, is the *prepared Natron* of the dispensatories, and contains a variable quantity of carbonic acid.

23. *Lime Water.*
This is made by putting pure water on quicklime, or fresh burnt lime; and after standing some time decanting the pure solution, See LIME.

24. *Barytic Water,*
Is made by dissolving pure barytes in water. For the preparation of pure barytes. See EARTHS.

25. *Strontian Water.*
Is made in the same manner. See STRONTIAN, article EARTHS.

26. *Sulphate of Iron.* See IRON.

27. *Nitrate of Silver.*
28. *Sulphate of Silver.* } See SILVER.
29. *Acetate of Silver.*

30. *Acetate of Lead.* See LEAD.

31. *Nitrate of Lead,*
Is made by dissolving lead, to saturation, in nitric acid. See LEAD.

32 *Nitrate of Mercury,*
Prepared with or without heat, is made by dissolving mercury to saturation in nitric acid, with or without the assistance of heat. See MERCURY.

33. *Prussiate of Potash.*
For the mode of making an impure prussiate for the use of the colour maker, see COLOUR MAKING. But for the purposes of the chemist, it is made generally in the following manner: Prussian blue is pulverized, and a solution of common potash is added, and digested on it; this is then decanted, and another portion added. This operation is to be continued until the colour ceases to be discharged. Filter the liquor, wash the sediment with water, till it ceases to extract any thing, mix the washings together, and pour the mixture into an earthen dish, in a sand-heat. When the solution has become hot, add a little dilute sulphuric acid, and continue the heat about an hour. A copious precipitate of Prussian blue will be formed, which must be separated by filtration, and assay a small quantity of the filtered liquor in a wine glass, with a little dilute sulphuric acid. If an abundant production of Prussian blue still takes place, the whole liquor must be again exposed to heat, with a little dilute sulphuric acid, and this must be repeated as often as necessary. Into the liquor thus far purified, pour a solution of sulphat of copper, into four or six times its weight of

warm water, as long as a reddish brown precipitate continues to appear. Wash this precipitate, which is a prussiate of copper, with repeated affusions of warm water; and when these come off colourless lay the precipitate on a linen filter to drain, after which it may be dried on a chalk stone. When the precipitate is dry, powder it, and add it by degrees to a solution of pure potash, which will take the prussic acid from the oxide of copper. This prussiate of potash, however, will be contaminated by some portion of sulphat of potash, from part of which it may be freed by gentle evaporation, as the sulphat crystallizes first. To the remaining liquor add a solution of barytes in warm water, as long as a white precipitate ensues, observing not to add more after its cessation. The solution of prussiate of potash, will now be freed in a great measure from iron, and entirely from sulphats, and by gentle evaporation, will form on cooling beautiful crystals. These dissolved in cold water, afford the best prussiate of potash, that can be prepared. If pure barytes be not at hand, acetate of barytes may be used instead; as the acetate of potash formed, not being crystallizable, will remain in the mother-water.

The common prussiate of potash, or properly triple prussiate of potash, may be formed, by digesting a solution of the carbonate of potash of the shops, in Prussian blue.

34. *Prussiate of Soda.*

May be prepared in a similar manner, to the foregoing.

35. *Prussiate of Lime.*

This preparation is made by digesting lime water on prussian blue. Made in this way, it is a triple prussiate.

36. *Succinic Acid,*

Is formed by the sublimation of amber. It is purified by solution and crystallization.

37. *Succinate of Ammonia,*

Is formed by saturating the succinic acid with the carbonate of ammonia, or the pure ammonia.

38. *Succinate of Soda,*

Is formed in the same manner.

39. *Phosphate of Soda.*

This phosphat is now commonly prepared by adding to the acidulous phosphate of lime as much carbonate of soda in solution as will fully saturate the acid. The carbonate of lime, which precipitates, being separated by filtration, the liquid is duly evaporated so as to crystallize the phosphate of soda; but if there be not a slight excess of alkali, the crystals will not be large and regular. Mr. Funcke, of Linz, recommends, as a more economical and expeditious mode, to saturate the excess of lime in calcined bones by dilute sulphuric acid, and dissolve the phosphate of lime that remains in nitric acid. To this solution he adds an equal quantity of sulphate of soda, and recovers the nitric acid by distillation. He then separates the phosphate of soda from the sulphate of lime, by elutriation and crystallization as usual. The crystals are rhomboidal prisms of different shapes; efflorescent; soluble in 3 parts of cold and 1½ of hot water. They are capable of being fused into an opake white glass, which may be again dissolved and crystallized. It may be converted into an acidulous phosphate by an addition of acid, or by either of the strong acids, which partially, but not wholly, decompose it. As its taste is simply saline, without any thing disagreeable, it is much used as a purgative, chiefly in broth, in which it is not distinguishable from common salt. For this elegant addition to our pharmaceutical preparations we are indebted to Dr. Pearson. In assays with the blowpipe it is of great utility; and it has been used instead of borax for soldering.

40. *Muriate of Lime,*

Is made by saturating the pure muriatic acid with lime: the carbonate of lime is generally added until the effervescence ceases. The solution is afterwards filtered.

41. *Alcoholized Soap,*

Is formed by dissolving white soap in alcohol, and filtering the solution. This preparation is generally called the solution of soap in alcohol.

42. *Alcohol.* See Alcohol.

43. *Sulphuret, and Hydrosulphuret of Ammonia.*

Ammonia may be combined with sulphur by mixing together two parts of muriate of ammonia, two of lime, and one of sulphur, and distilling in the pneumatic apparatus, with a small quantity of water in the receiver. A yellow liquor is obtained, containing sulphuret of ammonia, formerly known by the name of Boyle's fuming liquor. If sulphuretted hydrogen gas be passed through liquid ammonia, a compound of a green colour will be formed, which is hydrosulphuret of ammonia.

44. *Water, impregnated with sulphuretted Hydrogen,*

May be formed on letting them come in contact, by passing a stream of the gas through water.

45. *Hydrosulphuret of Potash* } These
46. *Hydrosulphuret of Soda.* }
preparations may be made by saturating their respective alkalies with sulphuretted hydrogen gas, by passing the gas through the alkaline solution; or by melting the alkalies with sulphur, and dissolving the compounds in water.

47. *Nitro Muriatic Acid, or Aqua Regia,*

Is usually made by mixing two parts of nitric acid and one part of muriatic acid.

48. *Oxygenized Muriatic Acid*

For the preparation of this acid, see BLEACHING, and Appendix to vol. 1.

49. *Phosphoric Acid.*

Although this acid is obtained from bones by calcination, and the addition of sulphuric acid, yet, by that mode, it is always impure; we have therefore added the following more approved process for obtaining it in a state of purity.

Phosphorus may be converted into this acid by treating it with nitric. In this operation, a tubulated retort with a ground stopper, must be half filled with nitric acid, and a gentle heat applied. A small piece of phosphorus being then introduced through the tube, will be dissolved with effervescence, produced by the escape of a large quantity of nitric oxide. The addition of phosphorus must be continued until the last piece remains undissolved. The fire being then raised to drive over the remainder of the nitric acid, the phosphoric acid will be found in the retort, partly in the concrete and partly in the liquid form.

We have made this acid by the acidification of phosphorus, in a white china bowl.

50. *Acetous Acid.* See ACETOUS ACID.
51. *Tartarous Acid.* See TARTAR.
52. *Boracic Acid.* See BORAX.
53. *Muriate of Tin.* See TIN.

54. *Muriate of Barytes,* }
55. *Nitrate of Barytes,* } Are made
56. *Acetate of Barytes,* }
by dissolving barytes, either the pure earth, or its carbonate, in the respective acids. For the preparation of pure barytes, see EARTHS, article Barytes.

57. *Nitrate of Potash.* See NITRE.

58. *Sulphuret of Lime,*

Which is made by melting two parts of sulphur and one of lime together, is used not as a reagent, but as an article, from which with cream of tartar, is disengaged sulphuretted hydrogen gas for the purpose of detecting the presence of lead in mines. See HAHNEMAN'S WINE TEST.

59. *Muriated Mercury, or Corrosive Sublimate.* See MERCURY.

60 *Ammoniated Copper,*

May be made by dissolving the oxide of copper in ammonia: if the dry powder, which remains after evaporation, be dissolved in water, one of the tests for the discovery of arsenic will be formed. See POISONS.

61. *Nitro Muriate of Platina.*

Is prepared by dissolving platina in nitro muriatic acid, which is a mixed acid prepared as directed in this article. This test is used to discriminate between potash and the other alkalies; it will produce a precipitate with a very weak solution of any salt with potash.

62 *Metallic Cylinders.*

Several of the metals, as has been observed, are made use of in experiments; for the convenience of use, they are generally cast or made into the cylindrical form. Copper, tin, zinc, and iron, are each of them employed; and occasionally silver, mercury, &c. The general principle on which they act may be noticed; to wit. Iron precipitates copper from its solution; copper, that of mercury and silver; and zinc, that of tin in the same manner. Sometimes, however, metals are used for a different purpose.

63. *Tincture and Infusion of red Cabbage.*

The latter is made by infusing the red leaves of this plant in a warm water of about 120 degrees for a few hours, and the former by digesting the leaves in diluted alcohol. To preserve the cabbage for a length of time, Mr. Watt advises, to mince the leaves, spread them on paper, and dry them with a gentle heat, and put them in closely stopped bottles. When to be used, digest some of the leaves in very dilute sulphuric acid, which will give a red colour; bring this to exact neutralization with chalk, so that the colour is a pure blue inclining to green or purple, and then pour off the clear liquor and employ it. By adding a little alcohol, it will keep for some time.

This test is changed to *red* by acids, and is therefore a test for uncombined

acid, and to *green* by alkalies, and is therefore a test for alkali.

64 *Muriated Alumine,*
Is made by saturating muriatic acid with alumine, and is used as a test to detect carbonate of magne ia in waters. By adding this test to a boiled water, a solution, a precipitate of carbonate of magnesia, will be found, if carbonate of magnesia is present, but in no other case, unless there be an excess of alkali, which may easily be neutralized.

65. *Muriate of Gold,*
Is formed by dissolving gold in nitro muriatic acid, prepared in the manner before noticed. It is used for several purposes. With a solution of tin, it forms a *purple* precipitate; see GOLD and TIN.

66. *Muriate of Strontian,*
67. *Nitrate of Strontian,*
68. *Acetate of Strontian,*

Are formed by dissolving the earth of strontian in the muriatic, nitric, and acetic acid. The solution, when effected, may be concentrated by evaporation.

69. *Sulphate of Soda.*
70. *Sulphate of Potash.*
71. *Muriate of Soda.*
72. *Sulphate of Magnesia.*
73. *Super Sulphate of Alumine and Potash.*
74. *Muriate of Ammonia.*
75. *Acetic Acid.*
76. *Arsenic and arsenous Acids.*

The above also constitute some of the substances used in sundry investigations; the saline compounds are formed by the combination of sulphuric or muriatic acid with alkaline or earthy bases. As these, with other compounds, are employed on some occasions, though rarely as tests, we will not trouble the reader with a further notice of them.

THERMOMETER. In the present cultivated state of philosophical knowledge, it can hardly be supposed that the reader has not seen a thermometer. Minute description is therefore unnecessary. But as the accurate construction and subsequent improvement of this instrument must greatly depend on the knowledge which those who use it may possess of the method of making it; and as we have no perfect account of this, there can be no doubt but a short relation of the whole process, from experimental knowledge, will be acceptable.

The tubes may be had at the glass-house; and the first care of the artist must consist in examining whether their cavities be equal or cylindrical throughout. This is done by immersing one end into mercury, and withdrawing it, after closing the other end with the finger. By this means a small quantity of mercury will enter the tube, which will occupy a longer space the deeper the tube is immersed. Lay the tube horizontally upon a graduated rule, and observe the length of the mercurial column in different parts of the tube, to which it may be made to run by inclining it more or less If the length continue invariably the same, it is a proof that the tube is uniformly cylindrical; but if otherwise, the diameter varies, and the tube cannot be used to make a good thermometer, unless the graduations in the different parts of the tube be lengthened or shortened, in proportion to the measures of the mercurial column.

Direct the flame of a large candle, a watch-maker's lamp, or, which is cleanliest and best of all, a lamp with alcohol, upon one end of the glass tube, by means of the blowpipe. The extremity will soon become red-hot, and in a state of imperfect fusion. Remove the tube from the flame, and blow into its other end, and the heated part will be inflated so as to form a bulb. This last inflation is the most difficult and laborious part of the business; but it may be performed with great ease and advantage, by previously fastening the neck of one of the small bottles of elastic gum, or India rubber, about the end of the tube; which, when the other end is ignited, may be pressed by the hand, so as to blow the bulb very commodiously, and without the introduction of any moist air.

Immerse the open end of the thermometer tube into some very clean dry mercury, that has been boiled, and warm the bulb with a candle; part of the air will be immediately heard rushing through the mercury; withdraw the candle, and as the bulb cools the mercury will rise in the tube. This will be facilitated by holding the tube as near a horizontal position as can be done, without raising its lower end above the surface of the mercury. In this way the bulb will be nearly half filled. Without altering the position of the apparatus, move the whole so that the bulb may be held over a candle. A small candle newly snuffed is best, because of the steadiness of its flame; and it will be necessary to wrap a piece of paper round the tube, to defend the finger and thumb from its heat. The mercury will soon boil, and most of the remaining air will be heard escaping from the bulb. As soon as this escape has ceased, remove the

bulb from the candle, and the thermometer will be suddenly filled with mercury from the vessel.

Take the thermometer thus filled out of the mercury, and wrap round its open end a piece of thin paper, in such a manner as to leave a cavity beyond the tube, at least sufficient to hold as much mercury as the bulb contains; secure this by wrapping it tight with packthread about the tube; then put a drop of mercury into the proper cavity, and apply the bulb again over the snuffed candle, holding the tube upright between the finger and thumb, or a pair of small pincers, at the part wrapped with paper and packthread; the mercury will soon boil, and about half the contents of the bulb will rush violently up the tube into the paper. Remove the bulb from the candle, and the mercury will suddenly return; then boil it again, and repeat the operation till the speedy boiling of the mercury, when placed over the candle, and the diminished noise and agitation, show, that the whole has been well heated, and deprived of the air or moisture, which might have adhered to it.

The operation of boiling will fail, if the mercury or the inside of the bulb be moist; for in this case the bulb is usually burst by the mercurial vapour: the explosion, however, is not dangerous; it is very likely to happen with bulbs blown by the mouth, unless they be kept some weeks in a dry place before they are filled. The same danger makes it prudent not to boil the mercury strongly the first or second time; and it is likewise of importance, to keep the bulb clear of the flame, as the contact of this last against the empty part of the bulb would melt it, and a hole would be immediately made by the excluded vapour.

After the boiling is completed, plunge the bulb into cold water, the temperature of which is known. Melting ice or snow (or snow and water) always has the temperature of 32° of Fahrenheit's scale. Then take off the paper, and put the bulb into the hand, and afterward into the mouth; this heating will cause some of the mercury to drop out of the tube Cool it again to 32°, by immersing it in the cold water, and mark where the mercury stands. The distance between this station and the top of the tube measures the interval between freezing and blood heat, or 32 and 95, which makes 63 degrees; and will consequently show whether the degrees will be large or small, and what extent the scale is capable of; that is to say, it will show whether the bulb be of the proper size. This last, supposing the judgment of the operator not sufficient to proportion the bulb nearly to the tube and the intended scale, might however have been more conveniently ascertained after the first filling, before the boiling had been undertaken.

When the number of degrees to which the length of the tube will extend is thus known, the operator must settle whereabouts he will have the freezing point; which may be nearer or farther from the bulb, accordingly as he intends the instrument to be used, more particularly to ascertain great degrees of heat or of cold. At this stage of the business, likewise, he may heat the upper part of the tube with the blowpipe, and draw it out to a fine capillary tube ready for sealing. The bulb must then be heated in the candle, till a few particles of mercury have fallen off the top of the tube; and notice must then be taken how much nearer the freezing point is to the bulb than before; which may be done by immersing it in the melting snow as before. If it be not as low as desired, the heating must be repeated, carefully observing not to throw out too much mercury at a time.

When the due quantity of mercury is thus adjusted, two candles must be prepared, the one to heat the bulb, and the other to close the tube. The blowpipe being in readiness, the upper part of the tube near the flame of one candle, and the bulb near the flame of the other, the mercury will rise, and at last begin to form a globule at the point of the capillary tube. At this instant the bulb must be withdrawn from the lower candle, at the same time that the flame of the upper is directed by the blowpipe upon the point of the tube. This last will be immediately ignited, and will close by the melting of its parts, before the mercury has perceptibly subsided. When the mercury has fallen, this closure may be rendered more secure from accidental breaking, by fusing the whole point of the tube till it becomes round.

If this business be properly done, the mercury in the instrument thus filled, will run backwards and forwards in the tube, immediately upon inverting its situation.

In the original graduation of thermometers, two fixed points of temperature are necessary. These are the freezing point of water, or temperature of ice or snow, at the instant of formation, or rather when it is just beginning to liquefy; and the boiling point of water, or temperature at which, under a known pressure, it is plentifully converted into steam For the settling of the freezing point nothing more is necessary than to immerse the thermometer so deep in melting snow or ice, as

that the mercury may be barely visible above its surface, and carefully mark the place at which it stands. The boiling point is not quite so easily ascertained; crude, hard, or saline waters acquire a greater heat in boiling than such as are purer; and the same water will acquire a greater heat under a greater pressure. For this last reason, the boiling point should be fixed according to the decision of the committee of the Royal Society; namely, when the barometer stands at 29.8 inches.

The best method is to provide a vessel somewhat longer than the thermometer, with a cover and two holes in it; one about an inch in diameter for the steam to escape; and the other smaller, for the thermometer tube to be fastened in it. When this is used, the thermometer must be fastened in the cover, so that the estimated place of the boiling point may be just above the hole. Water must be put into the vessel, not sufficient to touch the bulb of the thermometer when the cover shall be put on. The vessel must then be covered, a thin plate of metal laid on the steam-hole, and the water made to boil by heat applied to the bottom only. The thermometer will be then surrounded with steam, which will raise its temperature to the boiling point; and this point must be carefully marked on the tube. The following method may be more convenient to those who are not provided with such a vessel: Wrap several folds of linen rags or flannel round the tube, nearly as high as the supposed boiling point; hold the ball of the thermometer in the ascending current of boiling rain-water, about two or three inches below the surface; pour boiling water on the rags three or four times, waiting a few seconds between each time; and wait some seconds after the last time of pouring on water, in order that the water may recover its full strength of boiling, which is considerably checked by the pouring on the rags. The place where the mercury stands is the boiling-water point.

Notwithstanding the accurate adjustment of the fixed points of a thermometer, yet, if the tube be not truly cylindrical, or if the divisions be not adjusted to the inequalities of its diameter, the errors at the middle, between the two fixed points, may amount to more than a whole degree. A small error in the standing of thermometers may be occasioned by the varying pressure of the atmosphere, which alters the capacity of the glass; but it never amounts to so much as the tenth part of a degree. Spherical bulbs are least subject to this.

Thermometers, which, from the great length of their degrees, or for any other reason, are made to take in but a small part of the interval between the two fixed points, are usually graduated by comparison with a standard thermometer.

The very careful boiling of the mercury, as above described, is absolutely necessary for such thermometers as are to be sealed when full; for if there were any air or moisture left in the bulb, it would prevent the mercury in the tube from descending into the bulb, so that the tube would continue always full. These thermometers are undoubtedly the best; but the vacuum above the mercury does not seem to be an indispensable requisite. If a clean dry tube be filled with pure boiled mercury, and a small bulb be left at the top of the tube, to contain common air, in order that its expansion or condensation, produced by the change in the mercurial surface, may be inconsiderable; there will be few practical objections against such a thermometer, more especially if it be a secondary instrument, graduated by means of a standard. There are some thermometers made with tubes so very small, and bulbs so large in proportion to them, that they will not admit of boiling the mercury in them, but are filled with boiled mercury by means of a condenser. These are necessarily of the kind here mentioned.

The thermometers most in use at present are Fahrenheit's, Reaumur's, and Celsius's. The centigrade thermometer of the modern French writers is nothing more than the common Swedish thermometer, or that of Celsius under a new name. In Fahrenheit's scale, the number of degrees between the freezing and boiling-water point is 180; the freezing point being at 32°, and the boiling-water point at 212°, both above 0°, or the part from which the degrees are reckoned both ways. In Reaumur's scale, the number of degrees between these two points is 80, and the freezing point is called 0°, from which the degrees are reckoned both ways. In Celsius's thermometer, the interval is divided into 100°, and the freezing point is called 0°, as in Reaumur's. To reduce these scales to each other, it must be observed, that one degree of Fahrenheit's is equal to four ninths of a degree of Reaumur, and to five ninths of a degree of Celsius. Therefore, if the number of degrees of Fahrenheit, reckoned above or below the freezing point, be multiplied by 4, and divided by 9, the quotient will be the corresponding number on Reaumur's scale. Or if the multiplier 5 and the divisor 9 be used;

the quotient will give the degrees of Celsius's scale. And, contrariwise, if any number of degrees, either of Reaumur or Celsius, be multiplied by 9, and divided by 4, if of Reaumur, or by 5, if of Celsius, the quotient will give the degrees of Fahrenheit, reckoned either above or below the freezing point, as the case may be.

THUNDER. See METEOROLOGY.

TILE, a kind of thin brick, principally employed for covering the roofs of houses; though it is sometimes used for paving cellars, kitchens, areas, &c.

Tiles are divided into various sorts, according to the purposes to which they are applied. Thus, *plain tiles* are chiefly used for covering houses: and they ought to be 10½ inches in length, 6½ in breadth, and 5-8ths of an inch in thickness. *Ridge-tiles* are of a semi-cylindrical form, and, by the English statute, must be 13 inches in length, and also 6½ inches in breadth: they are chiefly laid on the ridges of houses. *Corner-tiles* are first made flat, in the manner of plain tiles, excepting that they are quadrangular; the two sides forming right lines; and their ends, arches of circles: previously to burning, they are bent on a mould, like ridge-tiles; and ought to be 10½ inches in length, and of a convenient size, being generally placed on the corners of roofs.

TILLAGE. See AGRICULTRE.

TIN. The ores of this metal have been noticed under the article ore.

The method of treating the ores of tin in Cornwall, England, is two-fold. The first that we shall mention, is that to which the tin-stone from the mines or vein-tin is subjected; the second is that by which the stream tin is reduced.

1. The vein-tin is procured by blasting, and when brought to the top of the pit, is in fragments of various sizes, and mixed so largely with quartz, argillaceous schistus, granite, and other impurities as rarely to contain more than 2 per cent. of metal. The first preparation that it receives, is being broken by hand hammers, about the size of hens' eggs, after which it is ready to be stamped. The stamping-mill is of the usual construction, (see the article GOLD,) except that the stampers are only three in number, and in front of the trough or coffer, there is inserted a plate of tin about a foot square, pierced full of holes, large enough to admit a moderate sized knitting-needle; that surface of the plates which is occupied by the rough extremities of the holes, is placed on the inside of the trough, by which simple and effectual contrivance, the holes are prevented from being plugged up by the ore. In proportion as the tin-stone is reduced to the proper degree of fineness, it passes with the water through these holes into a labyrinth, of very simple construction; here the oxyd of tin is separated from much of the lighter impurities, and by subsequent washing on a wooden table, it is sufficiently dressed to be sent to the roasting furnace; in this state it is called black tin, and is generally mixed in considerable proportion with mispickle, and iron and copper pyrites.

It is now calcined at a low red-heat in a large reverberatory furnace for several hours, in order to volatilize the arsenic and burn off the sulphur, (a part of this last after being acidified, combines with the oxyds of copper and iron.) The ore comes out of the roasting furnace, of a bright ochery red colour, owing to the decomposition and oxydation of the pyrites and mispickel, the oxyd of tin, if the operation has been well performed having undergone not the least alteration. The ore is now washed a second time, by which nearly the whole of the impurities are separated. The water employed in this process, being considerably impregnated with sulphat of copper is reserved, and afterwards decomposed, by the addition of pieces of old iron. The next step is the reduction, properly speaking; for this purpose a reverberatory furnace, about seven feet long and three and a half feet wide, is charged with seven hundred cwt. of roasted ore mixed with one-fifth of its bulk of culm (Welch small coal) no lime or any other kind of flux being made use of; the fire is kept up pretty brisk for about six hours, and the tin in proportion as it is reduced, sinks down to the bed of the furnace, being covered with a boiling hot bath of black scoriæ.

At the expiration of this period, the furnace is tapped by means of an iron bar, and the hot metal flows into a shallow pit at the foot of the furnace. When the whole of the metal has run out, the scoriæ are drawn out of the furnace with a rake, and a fresh charge is immediately thrown in. While the metal in the pit is red-hot, it throws up a quantity of slag very rich in metal, which is immediately returned into the furnace, and the melted tin after it has become sufficiently cool, is taken out with iron ladles and poured into moulds of granite, where it consolidates, each charge, affording on an average, from four to five hundred weight of metal. The first scoriæ are not entirely exhausted of metal, and are therefore transferred to the stamp-mill, and after-

wards washed, in order to separate the richer particles, which are then mixed with the next parcel of roasted ore.

The pigs of tin thus procured are next put without any addition, into a small reverberatory furnace, where they are exposed to a very gentle heat, the purest part of the tin, first melts as it is drawn off, forming the common grain tin; the more refractory part containing a small but variable portion of copper, arsenic and iron, is then brought to a state of fusion, and cast into pigs, forming the common or ordinary tin.

2. The stream tin-stone is not, we believe, found in any other part of Europe, than Cornwall, (Eng.) It differs from the former in its extreme purity, and absolute freedom from arsenic, and in its occurring in alluvial beds. The largest stream-tin work is at Carn, about two miles to the S. E. of Perran, not far from Redruth. It is situated in a valley, through which flows a stream, the course of which has been turned, for the sake of getting at the treasure concealed beneath its bed. The workmen first dig through a stratum about fifty feet thick of clay, shells and black earth, in which has been found hazel nuts, the antlers of an animal of the stag kind, a human scull, and a copper battle-axe; to this succeeds a layer of rounded stones, beneath which is the bed of tin ore, in grains and lumps of various sizes. The thickness of this bed varies from one to five feet, but the thickest part is comparatively the poorest. The whole of the superincumbent strata is cut away, as the workmen proceed, so that the general appearance of the cavity is that of a vast gravel or sand pit, near half a mile long, and about two hundred feet broad, which is kept clear of water by the powerful action of two water-mill pumps. The tin ore, as it lies quite loose, is merely shovelled into barrows, and wheeled to the head of the works, where it is thrown under a thin sheet of water which washes away the earth, leaving the pure ore behind. After this simple purification the ore is sent to St. Austle, a distance of about twenty miles, to be smelted. Here all the preparation for the furnace, that it receives is being bruised and passed through wire sieves, containing sixteen meshes in the square inch. The furnace employed is called in Cornwall, England, a blowing furnace, and is in fact only a blast furnace of the simplest construction, about seven feet high, and supplied with air from two cylinders, worked by an overshot water-wheel. The only fuel made use of is charcoal, and after the furnace is fully heated, it is fed at short intervals with the following charge, viz. three or four shovels-full of ore, and two or three half-bushels of charcoal, no flux of any kind being employed. At the bottom of the furnace is a small channel, through which the reduced tin is constantly flowing into a pit below, accompanied by a small quantity of slag, which is removed from time to time, and thrown again into the furnace. When the pit is full of tin, it is ladled out into an iron boiler, about three feet in diameter, with a small fire under it, to keep the metal sufficiently fluid: two or three large pieces of charcoal are then laid upon the tin, and plunged to the bottom by means of an iron instrument resembling a wheel, with a long handle fixed in the axle. A violent ebullition is immediately excited, and a little slag, which was before mixed with the metal, rises to its surface, and is scummed off. In a minute or two after, the metal is tried, by taking up a ladleful and pouring again into the mass, when if it appears quite bright like silver, and of an uniform consistence, the purification is complete, and nothing more is requisite than to cool it to a proper degree, and lade it into the moulds, by which it is formed into pigs, weighing from two to three hundred weight each. If the metal is poured too hot into the moulds, it is apt to be brittle. Good stream-tin affords from 65 to 75 per cent. of the very best and purest grain tin.

None of the Cornish tin may be sold till it has been coined; for this purpose a small piece is cut off from every pig and assayed; if it appears of the requisite purity, it receives the stamp of the Duchy, and pays to the Prince of Wales, as Duke, four shillings per cwt.

Tin is a metal of a yellowish white colour, considerably harder than lead, scarcely at all sonorous, very malleable, though not very tenacious. Wires cannot be made of it; but under the hammer it is extended into the leaves, called tin foil, which are about one thousandth of an inch thick, and might easily be beaten to less than half that thickness, if the purposes of trade required it.

The process for making tin foil, consists simply in hammering out a number of plates of this metal, laid together upon a smooth block or plate of iron. The smallest sheets are the thinnest. Its specific gravity is less than that of any other malleable metal. Long before ignition, it melts at about the 410th degree of Fahrenheit's thermometer, and by a continuance of the heat, it is slowly converted into a white powder by oxidation. Like lead, it is brittle when heated almost to fusion, and

exhibits a grained or fibrous texture, if broken by the blow of a hammer; it may also be granulated by agitation, at the time of its transition from the fluid to the solid state. The oxyd of tin resists fusion more strongly, than that of any other metal: from which property it is useful, to form an opake white enamel, when mixed with pure glass in fusion. The brightness of its surface when scraped, soon goes off by exposure to the air; but it is not subject to rust or corrosion, by exposure to the weather.

A preparation of the oxyd of tin is made for the purpose of giving the highest polish to steel, and to glass and metal mirrors, which is called tin putty. It is prepared according to Beaumé in the following way.

Some tin is melted in an iron vessel, with a low red heat, and the oxyd that forms on the surface, is successively removed till enough of it is procured. This is then spread on a red-hot muffle, and heated for half an hour, with frequent stirring, to complete the calcination of any particles of tin, that may be entangled in the oxyd. When cold it is powdered and sifted, and the finer part is again calcined for six or seven hours on a muffle. with a stronger heat, till it becomes almost white, and considerably hard, and in this state it forms the tin putty.

This substance is made in this country in a similar way. For the finest putty the purest grain tin is employed, which is calcined in a muffle, finely levigated and washed. This is nearly white, but the ordinary and cheaper sorts are browner, and are made by calcining old pewter, or a mixture of tin and lead, or any other alloy of these metals, which when in mixture, oxydate still more readily than either of the metals separately, and will easily take fire, as soon as the heat is raised to redness. As the oxyd of lead is very fusible, and the oxyd of tin very little so, the subsequent calcination in this case, is probably made at a lower heat, than when pure tin is used, otherwise the whole would run into a dense glass. This preparation must not be confounded with glazier's putty, which is only chalk beat up with linseed oil.

Concentrated sulphuric acid, assisted by heat, dissolves half its weight of tin, at the same time that sulphureous gas escapes in great plenty. By the addition of water, an oxyd of tin is precipitated.—Sulphuric acid, slightly diluted, likewise acts upon the metal; but if much water be present, the solution does not take place.

Nitric acid and tin combine together very rapidly, without the assistance of heat. Most of the metal falls down in the form of a white oxyd, extremely difficult of reduction; and the small portion of tin, which remains suspended, does not afford crystals, but falls down, for the most part upon the application of heat, to inspissate the fluid.

The muriatic acid dissolves tin very readily, at the same time that it becomes of a darker colour, and ceases to emit fumes. A slight effervescence takes place with the disengagement of a fetid inflammable gas. Muriatic acid suspends half its weight of tin, and does not let it fall by repose. It affords permanent crystals by evaporation. If the tin contains arsenic, it remains undissolved at the bottom of the fluid. Recent muriate of tin is a very delicate test of mercury. Mr. Chenevix says, if a single drop of a saturated solution of neutrallized nitrate or muriate of mercury, be put into 500 grains of water, a few drops of solution of muriate of tin, will render it a little turbid, and of a smoke gray. He adds, that the effect is perceptible, if ten times as much water be added.

Oxygenized muriatic acid dissolves tin very readily, and without sensible effervescence. The solution itself does not appear to differ from the foregoing.

A muriate of tin at a much higher degree of oxydizement, and very different in its properties, may be formed by an indirect process.

When equal parts of an amalgam of tin and mercury, and of corrosive muriate of mercury, are triturated together, and the mixture exposed to distillation in a retort, by a very gentle heat, a colourless fluid first comes over. This is followed by a thick white fume, which becomes condensed into a transparent liquor, called the fuming liquor of Libavius, on account of the copious fumes it emits, when the vessel that contains it is opened. On account of the considerable volatility of this liquid, it rises partly in the form of flowers to the top of the bottle, into which it is put; so that in the course of several months, it becomes entirely closed.

The residue, after the distillation by which the fuming liquor of Libavius is produced, consists of tin combined with the muriatic acid, calomel and running mercury, which sublime into the roof and neck of the retort; and at the bottom is found an amalgam of mercury and tin, covered with a saline combination of muriatic acid with tin, and such other metals as the tin may have been adulterated with. Much information may be derived from the foregoing experiments of Mr. Adet,

respecting the phenomena produced, when tin is dissolved in aqua regia.

Proust makes this fuming liquor without any amalgam. He mixed 24 ounces of corrosive muriate of mercury, with 8 ounces of powdered tin, and from these obtained 9 ounces of the liquor of Libavius. As a great excess of pure and oxyded tin was found in the residuum, he tried the proportion of 32 ounces to 8, but this gave him only 10 ounces of the liquor.

Pelletier prepared it by passing oxygenized muriatic acid gas, through a solution of muriate of tin, and expelling the excess of muriatic acid by heat.

Aqua regia, consisting of two parts nitric and one muriatic acid, combines with tin, with effervescence, and the developement of much heat. In order to obtain a permanent solution of tin in this acid, it is necessary to add the metal, by small portions at a time; so that the one portion may be entirely dissolved before the next piece is added. Aqua regia, in this manner, dissolves half its weight of tin. The solution is of a reddish brown, and in many instances, assumes the form of a concrete gelatinous substance. The addition of water, sometimes produces the concrete form in this solution, which is then of an opal colour, on account of the oxyd of tin, diffused through its substance.

The solution of tin in aqua regia, is used by dyer's to heighten the colours of cochineal, gum lac, and some other red tinctures, from crimson to a bright scarlet, in the dyeing of woollens.

The solution actually made by the scarlet dyer's, and called by them spirit, is prepared with that species of dilute nitric acid, termed single aqua fortis, to every pound of which are added, from one to two ounces of common salt, or sal-ammoniac. The acid thus prepared, will dissolve about an eighth of its weight of tin, which is previously granulated by being poured, when melted, into water briskly agitated by rods. This acid is still further diluted, and the heat of solution is checked by setting it in cold water, and adding the water very gradually. The process of solution is thus protracted to two or three days.

The acetous acid scarcely acts upon tin. The operation of other acids upon this metal has been little inquired into. Phosphat, fluat, and borat of tin have been formed by precipitating the muriat with the respective neutral salts.

Tin is soluble in the acid of tartar, and this solution is of importance in manufacture, as it is the method by which *wet tinning* is performed on copper and brass. Pins are whitened in this manner, but by a compound menstruum.

This process is easily performed: a solution of about one part of cream of tartar, two parts of alum, and as much common salt, is made in a moderate quantity of water, and tin filings, or granulated tin is thrown in, and the liquor boiled. The pins, which are made of brass wire, and perfectly bright, are then put in, and after remaining in the boiling liquor for a time, they are completely covered with a beautiful white uniform coating of tin, which is the state in which they are used.

It is not necessary to employ this mixture of salts for the mere tinning of copper or brass. Either of these three salts singly with tin filings will answer the purpose, but cream of tartar gives a duller and more leaden looking tinning, and alum on the other hand gives a very fine silver white but without gloss, so that the mixture above-mentioned is found to produce the most desirable hue.

In a chemical point of view this operation is curious, and appears to present a contradiction to the usual laws of affinity, for when tin is immersed in a common solution of copper, it precipitates most of the copper in the metallic state.

The circumstances requisite to produce a precipitate of metallic tin on copper, have been examined in an able set of experiments by Professor Gadolin, a Swedish chemist, an account of which is inserted in the Stockholm Transactions, for 1788, to which are added some other experiments and remarks by Baron de Gedda. It is to be observed, that the circumstances relating to the oxygenation of metals in their solutions in acids were very incompletely known at that time, so that we may now account for phenomena, which must have been inexplicable at that period. The facts, however, canrot vary, and are always valuable. This chemist chiefly confined himself to the action of a single salt, namely tartar, or its acid.

Earthy substances do not appear to affect this metal in the dry way. It detonates very rapidly with nitre, and becomes converted into an oxide, which partly combines with the alkali. All the sulphats are decomposed by tin. The tin becomes oxided, and the sulphuric acid converted into sulphur, which forms a sulphuret with the alkali, or earth of the salt, and dissolves part of the oxide.

Sal ammoniac is very readily decomposed by tin.

If the crystals of the saline combination of copper with the nitric acid be grossly powdered, moistened, and rolled up in

tinfoil, the salt deliquesces, nitrous fumes are emitted, the mass becomes hot, and suddenly takes fire. In this experiment the rapid transition of the nitric acid to the tin, is supposed to produce or develope heat enough to set fire to the nitric salts; but by what particular changes of capacity has not been shown.

If sulphur, in powder, be added to about five times its weight of melted tin, the two substances combine, and form a black compound, which takes fire, and is much less easily fused than tin itself. The mass is brittle, and of a needled texture.

A beautiful golden coloured species of sulphuret of tin has long been known in the arts, under the name of *aurum musivum*, or *mosaicum* (*Mosaic gold*). It is in the form of a scaly mass, sometimes crystallized in six-sided plates, very soft and glossy to the touch, readily rubbed down between the fingers, and when the colour is brought out by a little friction, having a fine golden metallic lustre. It is still prepared in pretty large quantities by some artists, and is supposed to be used principally in artificial bronzing and other ornamental purposes. It was formerly employed in medicine. A great number of receipts have been given for preparing it, most of which succeed nearly equally well, provided the same attention to management of the heat, &c. be observed. It is also interesting to experimental chemistry, and its properties have been examined by several excellent chemists, among whom may be enumerated Mr. Woulfe, the Marquis de Bullion, and M. Pelletier.

The old process for aurum musivum, and which is one of the best, is the following; as contained in the London Dispensatory.

Take 12 oz. of tin, 7 oz. of flowers of sulphur; sal-ammoniac and quicksilver, of each 6 oz.; melt the tin by itself, add to it the quicksilver, and when the amalgam is cold reduce it to powder, and mix it with the sulphur and sal ammoniac, and sublime the whole in a glass matrass, standing in a sand bath. Apply a gentle fire for some time, till the white fumes which arise copiously at first, begin to abate, then raise the fire till the sand becomes red hot, and keep it at this point, neither increasing nor diminishing it, for a considerable time, according to the quantity of the materials, till you judge the operation to be completed. The matrass being broken when cold, the mosaic gold is found at the bottom, and above it a sublimed substance, the composition of which will be presently mentioned.

The mosaic gold therefore is not a *sublimate*, but is a fixed substance, and it cannot be raised by heat unchanged. It weighs considerably more than the tin employed, but the actual product is extremely uncertain. A good deal of care is required in managing the fire, for if too slack, none of the mosaic gold will be formed, and if urged beyond a moderate redness it is again decomposed into a dark sulphuret of tin, totally without lustre. The proportion of the ingredients are variously given. Formerly, equal parts of all the substances were empoyed, but they may be reduced to the proportions here given without diminishing the product.

As soon as the ingredients are mixed, an odour of sulphuretted hydrogen is given out, which increases rapidly as heat is applied; and if the process be performed in a retort, with a receiver attached to it, a quantity of hydrosulphuret of ammonia or volatile liver of sulphur, comes over, which condenses in the extremity of the receiver, partly as a liquid, and partly in beautiful crystalline needles. The sublimate which is formed above the aurum musivum, and which is much less volatile than the ammoniacal hydrosulphuret, is an extremely compound substance, (in the usual way of preparing it) consisting chiefly of cinnabar, of muriated ammonia, and some muriat of tin, from which by a fresh sublimation an additional quantity of the aurum musivum may be obtained. This latter appears to be contained in the first sublimate, and indeed may often be found interspersed in it in shining hexagonal plates, but as aurum musivum alone cannot be sublimed, this portion is supposed to be formed by the muriat of tin and sulphur combining in the act of volatilization.

Tin unites with most of the metals, and some of these alloys are much used in the arts. Of these the most important are: the alloy of tin and copper, with other additions, which forms bronze, bell metal, speculum metal, &c.—The alloy of tin and lead in equal parts, which forms the common plumber's solder: the alloy of tin, lead, and bismuth, which forms the very fusible compounds described under Bismuth: the amalgam of tin and mercury used in silvering mirrors, the process of which is mentioned under the article Glass, and the alloys commonly called pewter.

Pewter was formerly more extensively used than, perhaps, any other metallic alloy, being the common material for plates, dishes, and other domestic utensils, but its use is now almost universally superseded by pottery, which is lighter, more

easily kept clean, and cheaper, though less durable. The name of pewter has been given to any malleable white alloy, into which tin largely enters, and its composition is so various, that hardly any two manufacturers employ precisely the same ingredients, and in the same proportion. The finest kind of pewter contains no lead whatever, but consists of tin with a small alloy of antimony, and sometimes a little copper. Wallerius gives the proportions of 12 parts of tin, 1 of antimony, and about one-forty-eighth of copper. A very fine metal is made of 100 parts of tin, 8 of antimony, 1 of bismuth, and 4 of copper. The use of these additions to the tin is to harden it, and preserve its whiteness; and this fine kind of pewter takes a very high polish, has a beautiful silvery lustre, and is not readily tarnished. Tin, with a little zinc or brass, makes a very fine, hard alloy. In all these superior kinds of pewter, the tin forms by far the greater part of the mixture.

It is to be observed, that the antimony is so intimately united to the tin, that it is not volatilized when strongly heated, or only in a very small degree, and it is not easily dissolved by any weak acid, so that there is no danger of producing the common effects of this metal in employing this kind of pewter. There is a natural limit to the use both of all the brittle metals, and of copper in alloying tin, which is the brittleness which they impart to the alloy when they exceed certain proportions. But it is not so with lead, which may be mixed with tin in any proportion, and the alloy will remain perfectly malleable; and this with, or without other smaller additions, forms the ordinary pewter, such as is used for measures for liquor, and many similar purposes, and in other countries of Europe, for many other domestic uses. As lead is by much the cheapest of the two metals, it is the interest of the manufacturer to employ it in as large a proportion as possible; but as much danger to health may be apprehended from this noxious metal, this subject was examined particularly by a commission from the French government of some very able chemists. These gentlemen found, that when wine or vinegar is allowed to stand in vessels composed of an alloy of lead and tin in different proportions, the tin is first dissolved, that the lead is not sensibly oxydated by these liquors, except at the line of contact of the air and the liquor, and that no sensible quantity of lead is dissolved even by vinegar after standing for some days in vessels that contained no more than about 18 per cent. of lead. Therefore, as no noxious effect is produced by the very minute quantity of tin which is dissolved, a pewter may be considered as perfectly safe which contains about 80 or 82 per cent. of tin; and where the vessels are employed merely for measures, a much less proportion of tin may be allowed. But the common pewter of Paris was found to contain no more than about 25 or 30 per cent. of tin, and the remainder was lead. The specific gravity of a mixture of tin and lead is *less* than the mean specific gravity of the same proportion of the two metals separately; consequently, the bulk of the alloy is greater than the bulks of the metals before union, which is the contrary to what happens in most other alloys. This alloy, when in equal parts, forms also the common plumbers' solder. When melted, it oxydates at its surface with great rapidity, much more than either of the metals separately, and this oxyd is the basis of the finest *Enamel white*.

The uses of tin are considerable. It is employed for many purposes in fine leaf, about the thickness of writing paper, when it is called *Tin foil*. This is made from the very finest tin, which is first cast into an ingot, then laminated to a moderate extent, and afterwards beat out with a hammer, with very great manual labour and skill, till it is brought to the requisite thickness, and extended perfectly uniformly without any flaw or break. The other uses of tin are, very largely, for tinning iron and copper, in pewter, solder, and other alloys; and the salts of this metal are employed in dyeing.

When tin is heated with phosphoric and charcoal, the metal appears to be very little changed. A combination, however, seems to take place, for the phosphorus burns on the surface of the metal when heated by the blowpipe. If small pieces of phosphorus be thrown on tin in fusion, it will take up from 15 to 20 per cent. and form a silvery white phosphuret of a foliated texture, and soft enough to be cut with a knife, though but little malleable. This phosphuret may be formed likewise by fusing tin filings with concrete phosphoric acid.

TINCAL. See Borax.

TIN-GLASS. See Bismuth.

TINNING OF IRON. See Iron.

TINNING OF BRASS, COPPER, &c. See Tin.

TITANIUM.—This metal was found in the state of oxide combined with others, in the vale of Manachan, in Cornwall, England, whence it was named manachanite, or oxide of titanium combined with iron. Klaproth found it in an ore named titan-

ite, or oxide of titanium, combined with lime and silex. It exists also in an ore called *red schorl of Hungary*, or *red oxide of Titanium*.

It is extremely difficult to reduce the oxide of titanium to the metallic state. However, the experiments of Klaproth, Hecht, and Vauquelin, have proved its reducibility.

According to the two latter, one part of the oxide of titanium is to be melted with six of potash; the mass when cold is to be dissolved in water. A white precipitate will be formed, which is carbonate of titanium. This carbonate is then made into a paste with oil, and the mixture is put into a crucible filled with charcoal powder and a little alumina. The whole is then exposed for a few hours to the action of a strong heat. The metallic titanium will be found in a blackish puffed up substance, possessing a metallic appearance.

Titanium has only been obtained in very small agglutinated grains. It is of a red yellow and crystalline texture, brittle, and extremely refractory. Its specific gravity is about 4.2; when broken with a hammer while yet hot from its recent reduction, it shows a change of colours of purple, violet, and blue. In very intense heat it is volatilized. Most of the acids have a striking action on this metal. Nitric acid has little effect upon it. It is very oxidable by the muriatic acid. It is not attacked by the alkalies. Nitro-muriatic acid converts it into a white powder. Sulphuric acid when boiled upon it is partly decomposed. It is one of the most infusible metals. It does not combine with sulphur, but it may be united to phosphorus. It does not alloy with copper, lead, or arsenic; but combines with iron. See Chenevix's paper in Nicholson's Journal, v. 134, and Accum.

TOBACCO, *various manufactures of*. See SNUFF, &c.

TOBACCO PIPES, *how made*. See POTTERY.

TOMBAC, a white alloy of copper with arsenic, which is sometimes called white copper. See COPPER.

TOOL, a general term, denoting any small implement, which is used both for manufacturing other complex instruments or machines, and also those employed in the mechanical arts.

Tools are divided into *edged-tools*, *spring-tools*, *pointed-tools*, &c. But, consistently with the advanced state of the present work, we shall only give an account of a patent, granted in January, 1795, to Mr. Arnold Wilde, for making plane-irons, sickles, scythes, drawing-knives, and other kinds of edged-tools, from a preparation of cast-steel and iron, incorporated by means of fire....He directs a piece of wrought-iron to be previously heated in the fire, and hammered; after which it should be formed of the requisite size: it is then to be fixed in a mould of proper dimensions, and in such a direction that, when the cast-steel is poured into the latter, the iron may settle in the middle, or on either side....Next, the steel must be melted in a crucible exposed to a strong fire; and, when it is nearly in a fluid state, the iron should be prepared in a *welding heat*. After clearing it from scales, or other extraneous matters, the iron is again to be fixed in the mould, and the fluid steel poured into the vacancy left for that purpose; when the whole will be united into one solid mass....The various tools, above-mentioned, may then be made of such compound metal in the usual manner; or by any method that should be deemed most convenient to the workman, or manufacturer.

The following remarks on the subject of Pettibone's patent for making edge-tools, accompanying a certificate of several eminent gentlemen of our city, may be here noticed.

From the "Useful Cabinet," published at Boston, in monthly numbers, for the Massachusetts Association of Inventors, and Patrons of Useful Arts, for the year 1808, *commenced at page* 26.

The superiority of edge-tools, made of cast-steel, is too well known to need any recommendation. The art of welding the best kind of cast-steel to iron, without injuring its texture, is an American discovery. Mr. Daniel Pettibone, of Roxbury, Massachusetts, is the inventor; for which he has a patent, dated March, 1806. This is a valuable invention; as tools made of cast-steel welded to iron, by his process, sufficiently prove.

Although we have tools imported from England, which are said to be cast-steel welded to iron; yet, according to the account of sir T. Frankland, communicated in 1795, to the Royal Society of London, it appears that the cast-steel which they weld to iron is a soft kind; little better, if any, than common steel. For he says, that the heat which they find necessary to weld their cast-steel would either melt the best kind, (such as Mr. Pettibone uses) or render it unable to bear the hammer; in which case, the goodness of the steel would be wholly ruined: so that Mr. Pettibone's discovery may be justly considered a great and valuable improvement, in extending the use of the

best cast-steel to those tools which require a part of them to be iron; and this too without the least injury to the goodness of the steel which it possesses before it is welded. His process is simple, not expensive, and easy to be understood. Edge-tool makers will find it advantageous to them to obtain of him a right to use this valuable art.

At the desire of Mr. Pettibone, we have evidenced and examined his process for welding iron and cast-steel together, and have seen several of the edged tools formed from the welded masses, by means of rollers, as described in his specification, which appear to us to be very good; and we have no hesitation in declaring, that we consider this invention of Mr. Pettibone, as likely to be of great benefit to the public, and well worthy of their patronage.

R. PATTERSON,
JOSEPH CLOUD,
ADAM ECKFELDT,
OLIVER EVANS.

Philadelphia, June 20, 1812.

TORREFACTION, an operation of roasting, by which ores are deprived of sulphur, arsenic, &c. which they might contain, and sundry articles, as rhubarb rendered crisp. See ORE.

TORTOISE SHELL, *imitation of.* See HORN.

TOUCHSTONE.—The black basaltes is used for examining the precious metals by the touch, and is commonly distinguished by this name. See ASSAY.

The touchstone, as described by some mineralogists, is a sub-species or variety of flint-slate. It is called also Lydian stone. The mode of trying metal, as gold or silver, by the ancients with this stone, is different from the moderns. The former drew the metal to be examined on the stone, and judged of the purity by the colour of the metallic streak; but the latter, after drawing the metal on the stone, ascertain its quality, or purity, by the agency of acids, such as aqua fortis, which has no effect on pure gold, if it be that metal which is examined. To ascertain the probable quantity of alloy in a specimen, a number of needles are obtained, which contain various known proportions of alloy, which, when rubbed on the stone, and examined in the same manner, will give a probable idea of the comparative purity, quality, and consequently value. This stone was called "the trier," from this circumstance; and the Lydian stone, according to Theophrastus, from its being found most abundantly in the river Timolus in Lydia.

TOUCHWOOD, or SPUNK, *Boletus igniarius,* L. a species of *fungus,* or sponge, which grows on the trunks, particularly those of cherry or plum-trees; where it frequently extends to a size of from two to eight inches.

The substance of this vegetable is very hard and tough, of a tawny-brown colour, and is sometimes employed, both in England and in Germany, as a substitute for *tinder:* with this design, it is boiled in a strong ley, or urine, after which it is dried, and boiled a second time in a solution of saltpetre.

TRAGACANTH (GUM).—This substance, which is vulgarly called gum dragon, exudes from a prickly bush, the *astragalus tragacantha,* Lin. which grows wild in the warmer climates, and endures the cold of our own, but does not here yield any gum. This commodity is brought chiefly from Turkey, in irregular lumps, or long vermicular pieces bent into a variety of shapes; the best sort is white, semi-transparent, dry, yet somewhat soft to the touch.

Gum tragacanth differs from all the other known gums, in giving a thick consistence to a much larger quantity of water; and in being much more difficultly soluble, or rather dissolving only imperfectly. Put into water, it slowly imbibes a great quantity of the liquid, swells into a large volume, and forms a soft but not fluid mucilage: if more water be added, a fluid solution may be obtained by agitation; but the liquor looks turbid and wheyish, and on standing the mucilage subsides, the limpid water on the surface, retaining little of the gum. Nor does the admixture of the preceding more soluble gums promote its union with the water, or render its dissolution more durable: when gum tragacanth and gum arabic are dissolved together in water, the tragacanth seems to separate from the mixture more speedily than when dissolved by itself.

TRAIN-OIL, is a general name for different sorts of fish oils; such as whale, seal, cod, elephant, pilchard oil, &c. Among these, whale oil is by far the most important article.

In the Greenland whale fishery, when the fat is all got off from the whale, it is cut in small pieces, and put up in tubs in the hold, cramming them very full and close; and when the ships get home, this fat is boiled and melted down into train oil. In the south sea fishery, the fat is boiled on board the ships, as the fish are caught.

Greenland oil is purer than southern oil, and fit for different purposes where

the latter will not answer; it is on that account generally worth four and five pounds per ton more

The seal is a native of the north seas; it is an amphibious animal with four feet, and called in many places the sea-calf, or sea-wolf. Its fat, which is near four inches thick, is converted into train oil, and the train which drops from that blubber, is not more rancid, than stale oil of olives.

Train-oil is used by leather-dressers, soap-boilers; for burning, &c.

TRANSPARENCIES, *painting of*.—The effect of this kind of painting, which has lately become very fashionable, though by no means a modern invention, is very pleasing, if managed with judgment, particularly in fire and moon-light scenes, where brilliancy of light and strength of shade are so very desirable.

The very great expense attending the purchase of stained glass, and the risk of keeping it secure from accident, almost precludes the use of it in ornamenting rooms; but transparencies form a substitute nearly equal, and at a very small expense.

The paper upon which you intend to paint must be fixed in a straining-frame, in order that you may be able to place it between you and the light, when you see occasion in the progress of your work. After tracing in your design, the colours must be laid on in the usual method of stained drawings. When the tints are got in, you must place your picture against the window, on a pane of glass framed for the purpose, and begin to strengthen the shadows with Indian-ink, or with colours, according as the effect requires, laying the colours sometimes on both sides of the paper, to give greater force and depth of colour. The last touches for giving final strength to shadows and forms, are to be done with ivory-black, or lamp-black, prepared with gum-water, as there is no pigment so opake and capable of giving strength and decision.

When the picture is finished, and every part has got its depth of colour and brilliancy, being perfectly dry, you touch very carefully with spirits of turpentine on both sides, those parts which are to be the brightest, such as the moon and fire, and those parts requiring less brightness, only on one side. Then lay on immediately with a pencil, a varnish made by dissolving one ounce of Canada balsam in an equal quantity of spirit of turpentine. You must be cautious with the varnish, as it is apt to spread. When the varnish is dry, you tint the flame with red-lead and gamboge, slightly tinging the smoke next the flame: the moon must not be tinted with colour.

Much depends upon the choice of the subject, and none is so admirably adapted to this species of effect as the gloomy gothic ruin, whose antique towers and pointed turrets finely contrast their dark battlements with the pale yet brilliant moon. The effect of rays passing through the ruined windows, half choaked with ivy, or of a fire amongst the clustering pillars and broken monuments of the choir, round which are figures of banditti; or others whose haggard faces catch the reflecting light: these afford a peculiarity of effect, not to be equalled in any other species of painting. Internal views of cathedrals, also, where windows of stained glass are introduced, have a beautiful effect.

The great point to be attained, is a happy coincidence between the subject and the effect produced. The fire light should not be too near the moon, as its glare would tend to injure her pale silver light; those parts which are not interesting should be kept in an undistinguishable gloom, and where the principal light is, they should be marked with precision. Groups of figures should be well contrasted; those in shadow crossing those that are in light, by which means the opposition of light against shade is effected.

TRIPOLI.—An earth, used for the polishing of metals, &c. similar to the rotten-stone. It was originally brought from Tripoli, whence its name; but it is now found in other countries besides Barbary.

TRITURATION, is an operation of grinding, performed in mortars, on porphyries, and in mills.

TROMPE.—The trompe, or blowing machine, is formed of a hollow tree which rests upon a cask whose lower head is knocked out, and the open part of the cask itself plunged to a certain depth under water. A current of water is made to fall through this wooden trunk upon a stone which is erected in the middle of the cask. The air becomes disengaged, and is obliged to pass out at a collateral aperture in the cask, by means of a tube which carries it to the lower part of the furnace. This air is afforded, 1. by that air which the water carries along with it: 2. by a current which passes through apertures made at the distance of six feet from the summit of a tree, and called trompilles. We use the French names, because we do not know of any appropriated English terms.

The dimensions of a good trompe, according to Chaptal, are the following:

Length of the tree, or wooden trunk, from its summit to the side apertures or trompilles, six feet.

Length of the tree, from the trompilles to the cask, eight feet.

Height of the cask, five feet.

Diameter of the cask, four feet six inches.

The form of the internal part of the trunk, above the trompilles, is that of a funnel, whose superior opening is eighteen inches, and its inferior diameter five.

The diameter of the cavity of the tree, below the trompilles, is eighteen inches.

The diameter of the trompilles is six inches.

Dr. Lewis, in his Philosophical Commerce of Arts, treats expressly on this simple and useful instrument, on which he made many experiments. The following remarks, references, and investigations, are abridged from his work.

The earliest method of animating the large fires of the furnaces for smelting ores, appears to have been by exposing them to the wind. Such was the practice of the Peruvians before the arrival of the Spaniards in that country. Alonso Barba relates, that their furnace, called guairas, were built on eminences, where the air was freest; that they were perforated on all sides with holes, through which the air was driven when the wind blew, which was the only time the work could be carried on; that under each hole was made a projection of the stone work on the outside, and that on these projections were laid burning coals to heat the air before its entrance into the furnace. Some authors speak of several thousands of these guairas burning at once on the sides and tops of the hills of Potosi.

It is said that several remains of a like rude process, are to be seen in some parts of our own country. The old blomery hearths, as they are called, for the running down of iron ore, are all on the tops of hills; a situation which can scarcely be supposed to have been chosen on any other account than for the conveniency of the wind, being in other respects extremely incommodious.

The gradual succession of bellows to this insufficient mode of supplying air, cannot perhaps be traced. It appears, that at some of our iron-furnaces, and others, the bellows were formerly moved by a handle, as those of the smith's forge, or by the pressure of the foot upon a treadle, or by other means requiring the strength of men; and that since the force of water has been called in aid to move them, the quantity of ore run down has not only been far greater, but the separation of the metal more complete.

The first account that is to be met with of a machine for propelling air into furnaces, by a fall of water carrying down air with it, is of one at the copper or brass furnaces at Tivoli, near Rome. In this machine a square wooden pipe of considerable width, and open at both ends, is placed upright. A stream of water runs in at the top, and is discharged at the bottom; and about the middle of the height of the pipe a smaller horizontal one is inserted, which reaches to the furnace, and is said to convey to it a strong blast of air.

According to Mr. Belidor, a pipe with air holes, inserted into an air vessel, is used for this purpose in some parts of France.

Mr. Mariotte gives an account of a contrivance for blowing fire by a fall of water, which consists of a funnel and pipe, without air holes, inserted into an air vessel.

Mr. Stirling describes a machine erected in Scotland, for blowing air into the furnace in which lead ores are smelted, and for conveying fresh air into the works. This machine consists of a funnel and pipe, with air holes, inserted into an air vessel.

The blowing machines used in Dauphiny, for the forges and smelting furnaces, have a great resemblance in their general structure to the foregoing.

In the county of Foix, the blowing machines, as described by Reaumur, are considerably different from the foregoing. The pipe is rectangular, and the part above the choak divides into three funnel-shaped partitions. On the top is a reservoir or cistern of water: and two of the partitions, close on all sides, pass up above the surface of the water, for carrying down air, and thus supplying the place of the lateral air holes: the water enters into the third partition, which is only the space between the two foregoing, and which has but two sides, formed by the two opposite sides of the others.

Mr. Barthes gives a minute description of a blowing machine at the forge of St. Pierre, on the river Obriou. Its general structure is nearly the same with that of Foix, but the height of water above the choak much less.

Dr. Lewis's trials, though not carried to such a length as he could have wished, satisfied him and those who assisted at them, that much more air is to be obtained by dividing the stream by means of a cullender, than by any other me-

thods that have been tried; and that with such a machine as that of St. Pierre above described, a stream of a hundred and fifty gallons at most in a minute is sufficient to produce a continued blast from a pipe of three quarters of an inch bore, of such strength as to support a column of water of three feet or more.

His summary view of the most material particulars which his experiments have discovered, with regard to the perfection of the structure of blowing machines, and his description from them of such a machine as promises to be the most effectual, are as follow:

The bottom of the reservoir of the water should be about fourteen feet above the level of the ground: we need not be very solicitous about procuring a greater height; for though a greater, would be of some advantage, yet this advantage appears to be much less considerable than has been commonly imagined. In the channel by which the water is conveyed, are to be placed gratings of different sizes; and before the aperture a finer grating, which may be either a perforated iron plate or a wire sieve, to serve as strainers for keeping back such matters as would obstruct the apertures which the water is afterward to pass through. The stream should enter at one side, or be so managed, that the water in the reservoir or funnel may not be agitated by it, or put into a spiral motion, which Dr. Lewis's experiments showed to be very injurious.

In the bottom of the reservoir is to be made a round hole, for admitting the upper end of a cylindrical pipe of copper or cast iron, five or six inches in the bore, and seven feet long. To the end of this pipe is to be fitted a cullender about a foot long, with the holes triangular, of half an inch each side; and six or seven spaces from top to bottom, at equal distances, must be left without holes, for admitting air to pass down to the lower streams. All the holes should be directed downwards, that the streams may not be forcibly projected against the sides of the pipe which is to receive them, so as to have their velocity too much diminished.

If there are six of the perforated spaces in the cullender, the number of holes in each may be twenty; so that the whole number will be one hundred and twenty. The side of each of the triangular holes being half an inch, the area of each will be the eighth part of a square inch, and the sum of their areas will be fifteen square inches. The quantity of water running through one aperture of such an area, at the depth of seven feet and a half under the surface, comes out on calculation about six hundred and twenty-two gallons in a minute; but the real quantity will doubtless be much less than this, on account of the great friction of the water in passing through a number of small holes, and of the resistance of the air, which increases in a very high ratio according to the increase of the velocity and enlargement of the surface: it is in part to make up for these retardations, that the pipe is directed to be made so high. The surface of the water is here above thirteen times greater than if it passed all through one circular aperture.

Both the pipe and the cullender should have a flanch or rim round their orifices, and be secured to one another by screws passing through the rims of both, with a plate of lead between them to make the juncture tight, as commonly practised in joining iron pipes for water works. This way of joining them admits the cullender to be taken off and cleaned, when a diminution of the effect of the machine shows the holes to be choked up; which, however, it is apprehended, will seldom if ever happen.

As the holes will permit more water to run through, than may at all times be wanted, it is proper to have some contrivance for occasionally closing a part of them. This may be effected by means of a thin copper pipe, open at both ends, as high as the cullender, and of such width as just to drop into it. It will be easily conceived, that when this register is let entirely down, the lateral holes will be covered, and the water admitted only to those in the bottom; and that by raising it farther and farther, more and more of the lateral holes will be uncovered. The register is to be hung by a wire to a cross-bar over the reservoir, by which it may be raised or lowered; and a scale or divided board may be adjusted against the upper part of the wire, for showing the height of the register, or the number of holes closed by it.

The most commodious and effectual way of admitting air to the water appears to be that of hanging the throat of the funnel, in this case the cullender, within the wider receiving pipe; for by this means the air is admitted freely and uniformly all round. This last pipe should likewise be of iron or copper, twelve inches in diameter, and spread out at top to the width of sixteen or eighteen inches, that a large space may be left round the cullender: this space should reach three or four inches above the up-

permost perforations of the cullender, to prevent any of the water from being dashed over the top.

A pit is to be sunk in the ground, not less than six feet deep. In this is to be placed an air vessel, made of wood lined with lead, without a bottom, three or four feet in width, and ten or eleven high. The vessel should be supported on feet of a proper strength, with sufficient spaces between them for the water to pass freely out: this way is preferable to the common one of placing the lower edge of the vessel on the bottom of the pit, and cutting an aperture in the side, because the height of the aperture is so much taken off from that of the vessel The reservoir being fourteen feet above the ground, and the upper pipe and cullender reaching down eight feet, only six feet remain below the cullender; so that the air vessel having six feet sunk, the ground will reach nearly up to the cullender, and almost the whole height of the undermost pipe will be included within the vessel. This pipe may be above nine feet long, three feet or more of it going down into the pit; which three feet are here an entire gain in the height of the fall, for the pipe in the other machines comes at most no lower than the level of the ground where the water runs off on the outside. This height is gained in virtue of the compressed air in the vessel pushing down the water below: it may be always as great as the height to which the water is intended to rise in the guage. At the distance of five or six inches under the orifice of the pipe is to be placed the concave iron plate or stone for the water to fall on. In the top of the air vessel is to be fixed the guage and the blowing pipe.

Such is the general construction of the blowing machine, which (says Dr. Lewis) promises to be particularly useful in cases where water is scarce, or where the want of a natural fall renders it necessary to raise, by very expensive means, the great quantities requisite for working the common bellows. Dr. Lewis thinks too, that one of these machines will be sufficient for the iron forge, and for sundry other purposes where the quantity of air is not required to be very great; that it will be less expensive, on account of the durability of its materials and the simplicity of its structure, than any kind of bellows now in use; and what is of principal importance, that much less water will serve for working it. He adds, in cases where one of the machines cannot supply air enough, as for the large iron smelting furnace, two pipes may be used, both fed by one reservoir, and entering into one air vessel. The using of two pipes appears more eligible than enlarging the bore of one; for air cannot be so freely introduced into a large body of water, though divided into streams by the cullender, as into two smaller ones of equal quantity.

It may be observed, that the blast will be stronger in a dense state of the atmosphere, than when it is more rare or expanded, a greater quantity of air being then introduced under an equal volume. If, therefore, the quantity of water has been adjusted so as to raise the guage to a proper height when the air was light, it will frequently happen, that the same quantity of water shall raise it higher, and consequently, if no greater height is required, that a part of the water may be saved. As the guage of the machine discovers by inspection the variations in its effect, the register affords convenient means of regulating its power, and increasing or diminishing the quantity of water.

The method of blowing in our large furnaces is by iron bellows or machines, worked by a steam engine. Some years ago I had a conversation on this subject with one of our most eminent iron masters, whose name I should be glad to mention as a credit to myself, if I had at this time an opportunity of asking his permission.

The air machines are iron cylinders six feet in diameter, in which a piston works with a stroke of seven feet in length. Each stroke, therefore, intrudes 198 cubic feet of air. At best the rate of working is sixteen strokes in a minute. The density of the air is such that it will raise three pounds weight on a square inch hole in the piston, in which effect the stroke has some part. For the pressure in the reservoir is less, being about two pounds on the same surface. The reservoir, called the regulating belly, is a large close chamber open below, and surrounded with a sufficient mass of water to rise within it, and by its reaction keep up the density of the air with which its upper part is supplied from the cylinder. The differences of height between the surfaces of the water within and without the reservoir is between six and seven feet, and the rise and fall at each stroke of the piston is about four or five inches on the outer surface. I think he afterward said two or three. From this last datum we may deduce the size of the regulating belly or its horizontal section. For its surface will be, to that of the piston, inversely as this rise is to the length of the stroke. If the medium of the first numbers be taken, its surface will be 19 times

that of the piston, which is 28¼ square feet, that is to say, 536 square feet, or a square whose side is 23 feet. But if the medium of the second numbers be taken, the surface will be 45 times that of the piston, that is 1271 square feet, or a square whose side is about 36½ feet. The larger this surface, the steadier the blast. From the regulating belly proceeds the nozzle, or twyer, (tuyere) as it is called. Its diameter at the aperture is one, two or three inches. They have sometimes enlarged them for experiment as far as five; but they then found the apparatus not to supply the air quickly enough, or at least not with the same advantage as when a smaller aperture was used.

If we attend to the height of the water on the outside of the reservoir, we shall find the force of this apparatus to be greatly beyond that of the other bellows in use. Six or seven feet of water upon the base of a square inch will give 72 or 84 solid inches, and those at a thousand ounces to the cubic foot, or 1728 inches, will give 41 ounces, or two pounds nine ounces for the pressure upon a square inch, represented by the first of these numbers. The second number will give near 48 ounces, or three pounds. These pressures referred to a column of mercury, which is a very usual and convenient method of admeasurement, will correspond to 5.3 and 6.2 inches elevation of that fluid; that is to say, at most not one-fifth of an atmosphere.

In some of the early volumes of the Abridgment of the Transactions, there is an account of a method of conveying air to vast distances, through pipes for the purpose of blowing, and as I think, speaking from recollection, for the communication of mechanic effect. This scheme was put in practice by the father of the ironmaster from whom the preceding information was received. The project, which did not succeed, cost four thousand pounds. Three engines were erected, consisting of bellows worked by large water wheels, at a fall of water eighteen hundred yards distant from the iron work to which the air was intended to be conveyed. A pipe, ten inches diameter, conveyed the air from the engine to the works, and the stream of air was never so strong as to blow out a candle. So I find it in my notes; but I think, from recollection, the expression was to affect the flame of a candle, and certainly a very gentle breath of air was meant. The engine worked but a few strokes before it stopped. The proprietor concluded, that the pipe was in some part designedly obstructed; but upon advice, he put a cat into the pipe, which walked through it and came out at the other end.

It remained, therefore, to ascertain whether the obstruction of the air arose merely from the length of the pipe For this purpose holes were cut in the pipe at various distances from the end at which the air entered and proper coverings prepared, that each might be opened at pleasure. It was found, that the engine worked slower, the remoter the hole which was opened, the wind issuing of course with less strength; and when the hole was made at a certain distance, it stopped. I did not ask the distance. It is said, that the passage of air from a blowing machine to its place of escape is considerably impeded through pipes of the length of 40 or 50 feet. The fact, which is perfectly authentic, is certainly very curious. Whether it is to be ascribed to the loss by friction of a momentum, in which the velocity is so great and the mass so small, or whether there be any effect similar to that stickage which takes place when wool, or other elastic bodies are rammed into a tube, must be determined from a numerical estimate of all the facts, and may perhaps require new experiments. I cannot help, however, entertaining the opinion, that the former cause is the most effectual in this business; and that the undertaking here described might have been made to answer, by enlarging the diameter of the tube. For if the impediment be friction arising from the velocity of the mass, that element will diminish in proportion as the diameter of the tube is increased, and the quantity of surface rubbed against by the same mass of air will not alter. Hence it should follow, that if a tube, of an inch diameter and three feet long, do not perceptibly resist the passage of the air, another tube, thirty feet long, will afford no more resistance, provided its diameter be ten inches, that is to say, proportional to its length.

TRUNDLE. See Mechanics.

TUNGSTEN.—Tungsten is obtained from a mineral called *wolfram*, which contains the oxyds of tungsten, manganese and iron, with earthy matter. Mineralogists call tungsten a mineral, which contains the oxyd or acid combined with lime. Although several attempts have been made by different chemists to obtain this metal, yet very few have succeeded. It may be produced in the following manner, according to Rechter.

Let equal parts of tungstic acid and dried blood be exposed for some time to a red heat in a crucible; press the black powder which is formed into another

smaller crucible, and expose it again to a violent heat in a forge for at least an hour. Tungsten will then be found, according to this chemist, in its metallic state in the crucible.

To produce the metal pure, the following process has been recommended.

Boil finely pulverized wolfram in strong muriatic acid for some time; separate the solution; the residuum contains a yellow powder; it is to be washed, dissolved in ammonia, evaporated to dryness, and mixed with a fine charcolian powder, and exposed to a very intense heat for about 20 minutes in a covered Hessian crucible — Small grains of pure tungsten will be found at the bottom of the crucible.

Tungsten in its metallic form, was first procured by Messrs D'Ethuryrs in 1782.

Tungsten, or *Scheelium* of the Germans, is of a grayish white colour. Its specific gravity is 17.3. It requires for fusion about 170° Wedgwood. It combines with oxygen, forming a blue and yellow oxyd. The prot oxyd is blue, and the per oxyd is yellow, known by the name of tungstic acid.

TURF. See Peat.

TURNSOLE. See Litmus and Dyeing.

TURKEY STONE. *Cos Turcica.* This stone is of a dull white colour, and often of an uneven texture, some parts appearing more compact than others, so that it is in some measure shattery. It is used as a whetsone: and those of the finest grain are the best hones, for the most delicate cutting tools, and even for razors, lancets, &c. Its specific gravity is 2.598. It gives fire with steel, yet effervesces with acids. Kirwan found, that 100 parts of it contain 25 of carbonate of lime, and no iron.

There probably are two sorts of stones known by this name, as Wallerius affirms, that which he describes, neither to give fire with steel, nor effervesce with acids. Workmen affirm, that this stone hardens with oil. The value of such specimens as contain a very fine grit, or siliceous part, is much greater than that of common samples. Artists select them by trial; but it is not generally known, that most of these stones, have a fine and a coarse side, and ought therefore to be sawed with an attention to this circumstance. It naturally arises from the stone having been formed from subsidence in water.

This stone is found in several places in the United States, equal in quality to the imported.

TURKEY-RED. See Dyeing.

TURKISH, OR ORIENTAL PASTE. The jewellers of Paris have of late years, formed many handsome ornaments, such as ear-rings, bracelets, broaches, made of a kind of stone or perfumed paste. On the examination of this mock jewellery, it has been found to be made from the Japan earth, known by the name of *mimosa catechu*, an article well known in the *materia medica*, and being mixed with musk or ambergris, to render it perfumed, and diluted with gum dragant, it is rendered into the requisite form by proper moulds, according to the following process:

They first take the requisite quantity of *catechou*, reduced into small bits, on this is then poured eight times its weight, in equal quantities of strong water and vinegar, and rose water; this mixture is then put into a glass-bottle, stopped with a piece of moistened bladder, pierced with a pin-hole to give access to the air, it is then placed in a sand-bath, or on a stove moderately heated, until the catechou is dissolved.

Thus dissolved it is suffered to grow cool, and then filtered through gray paper; it is then put into a retort, to which is attached a recipient. The whole of the spirit is then distilled, until it emits nothing but clear water.

The residue at the bottom of the retort is then put into a china bowl, and to every ounce of dissolved catechou is then added half a drachm of the solution of gum dragant, and the whole is mixed up into a thick paste, which congeals in the cold. Whilst the paste remains ductile, there is added the quantity of from four to six grains well pulverized, to the quantity of every half ounce, and the whole is to be well mixed up together.

This preparation of the paste is then put into the requisite shaped moulds, made of either copper or brass, and the inside of which must be well polished, and anointed with oil of almonds or jessamine, to prevent the paste from adhering thereto. It is then covered over, and left to harden gradually.

TURMERIC, (terra merita,) curcuma longa, is a root brought to us from the East Indies. Berthollet had an opportunity of examining some turmeric, that came from Tobago, which was superior to that which is met with in commerce, both in the size of the roots, and the abundance of the colouring particles. This substance is very rich in colour, and there is no other which gives a yellow colour of such brightness; but it possesses no durability, nor can mordants give it a sufficient degree. Common salt and sal ammoniac,

are those which fix the colour best, but they render it deeper, and make it incline to brown; some recommend a small quantity of muriatic acid. The roots must be reduced to powder to be fit for use. It is sometimes employed to give the yellows made with weld a gold cast, and to give an orange tinge to scarlet; but the shade the turmeric imparts, soon disappears in the air.

Mr. Guhliche gives two processes for fixing the colour of turmeric on silk — The first consists in aluming in the cold for 12 hours, a pound of silk in a solution of two ounces of alum, and dyeing it hot, but without boiling, in a bath composed of two ounces of turmeric, and a quart (measure) of aceto-citric acid, mixed with three quarts of water. The second process, consists in extracting the colouring particles from the turmeric, by aceto-citric acid, in the way described for Brazil-wood, and in dyeing the silk alumed, as already mentioned in this liquor, either cold or moderately warm. The colour is rendered more durable by this, than by the former process.

The first parcel immersed, acquires a gold yellow; the colour of the second and third parcels, is lighter, but of the same kind; that of the fourth is a straw colour. Mr. Guhliche employs the same process, to extract fine and durable colours from fustic, broom, and French berries: he prepares the wool by a slight aluming, to which he adds a little more muriatic acid. He seems to content himself in these cases with vinegar, or some other vegetable acid, instead of his aceto-citric acid, for the extraction of the colour; he directs that a very small quantity of solution of tin, should be put into the dye-bath.

TURPENTINE, and other resinous products of the Pine.

Under this head, we shall describe the methods of procuring and preparing a variety of very important articles of commerce, such as turpentine, resin, pitch, tar, &c. which are employed so extensively in ship-building and rigging, in varnishes, and many other purposes of inferior interest.

All these are the products of one or other species of pine, and sometimes the same substance is yielded by different species, as all the varieties of the native resin, or turpentine, have a very great resemblance in chemical properties.

There are three varieties of pine turpentine, commonly known under that name in Europe.

1. The common turpentine, obtained chiefly from the *Pinus Sylvestris* (Scotch Fir.)

2. The Strasburgh turpentine yielded by the *Pinus Picea* (Silver Fir.)

3. The Venice turpentine procured from the *Pinus Larix* (Larch.) To these may be added two liquid turpentines.

4 The Carpathian or Hungary balsam, which it exsudes from the *Pinus Cembra* (Siberian Stone Pine.)

5. The Canada balsam, the resinous juice of the *Pinns Balsamea* (Balm of Gilead Fir.)

The fine fragment Chio turpentine, is not procured from a pine, but from a low shrub (the *Pistacia Lentiscus*) which will be described in the next article.

Of the three first-mentioned turpentines, the Venice is the thinnest and most aromatic, the Strasburg the next, in these qualities, and the common, is the firmest and coarsest. The two former are often adulterated by a mixture of the common turpentine, and oil of turpentine, and it is to be observed, that the terms Venice and Strasburg turpentine, are not now appropriate, as they are procured from various countries.

Common turpentine is obtained largely in the pine forests, in the south of France, in Switzerland, in the countries on the north of the Pyrenees, in Germany, and in many of the southern states of North America. The greater part of what is consumed in Europe, is imported from North America. The method of obtaining it, is by making a series of incisions through the bark of the tree, from which the turpentine exsudes, and falls down into holes, or other receptacles at the foot. The process is described very accurately by Duhamel and Moringlane, as practised in the south of France.

The fir is generally allowed to remain untouched, till it is thirty or forty years old. When it is to be worked, which is early in the spring, a small hole is first made in the ground at the foot of the tree, the earth of which is well rammed, and serves as a receptacle for the juice. The coarse bark is then stripped off from the tree, a little above the hole down to the smooth inner bark, after which a portion of the inner bark together with a little of the wood, is cut out with a very sharp tool, so that there may be a wound in the tree about three inches square, and an inch deep. Immediately afterwards, the turpentine begins to exsude in very transparent drops, which escape chiefly from the wood, immediately under the inner bark. The hotter the weather is, the greater is the supply of resin, and to facilitate the supply, the incisions are enlarged every three or four days, by cutting off thin slices, till at the end of the year, it is about

a foot and a half wide, and two or three inches deep. The whole time during which the turpentine flows, is from the end of February to October. In the winter it entirely ceases, but in the ensuing spring, a fresh incision is begun a little above the former, and managed in the same manner. This practice is continued annually, for about twelve or fifteen years, in some parts, and in others a shorter time, on the same side of the tree, till the latter incisions are so high, as to be out of reach without the assistance of steps; after which the contrary side of the tree is begun upon, and worked in a similar manner for as many years, during which time the first incisions are grown up, and are fit to be cut afresh. In this way, a healthy tree in a favourable soil, may be made to yield, from six to twelve or more pounds of turpentine annually, sometimes for a century, and even the timber is not soon injured by this constant drain.

The flow of turpentine discontinues altogether about October, and the liquid resin collected during the year from each tree, is put together for further purification. But a considerable quantity of the resin, has concreted during that time around the incision, particularly as the heat declines; and in the winter when it has hardened considerably it is scraped off, and forms what is technically called Barras, or in some provinces Galipot, which differs from the more liquid turpentine in consistence, and probably contains a less proportion of essential oil -- The galipot is much used in making flambeaux, when mixed with suet, but the greater part of it, as well as the liquid turpentine, is subjected to further processes.

These we shall resume when we have described the method of obtaining the other kinds of turpentine, which however, is so very similar that a few words will suffice.

The *Strasburgh turpentine*, the produce of the silver fir, is the most fragrant of all the pipe turpentines, and only inferior to the true Chio, but it is not often seen in the shops. It is obtained by rude incision of the bark by the peasants in the vast pine forests on the western Alps. The first cut is made as high as the hatchet will reach, and these are renewed annually from above downwards to within a foot of the ground. But the finest kind of turpentine yielded by this tree, is that which exudes from soft tubercles or swellings of the inner bark. The peasants carry with them a large cow's horn, with the point of which they pierce these tubercles and collect the juice in its hollow. Only a few drops are yielded from each tubercle, so that this turpentine is rare, and bears a higher price. It is called technically *Bigoin* or *Oil of Pine*, and when thickened by exposure to the air, it remains clear like mastich, whereas the turpentine obtained from the same tree by incision of the bark, becomes white and opake by age.

The true *Venice turpentine*, or resin of the larch, is obtained from the Tyrol, and Savoy, and also from Dauphiny, by boring holes about an inch in diameter, with a gentle descent, in the most knotty parts of the tree. To these are adapted long perforated pegs, which serve as gutters to convey the juice into troughs placed beneath. It is yielded during the whole of the summer, and is simply purified by straining through hair sieves. A full-grown larch will sometimes yield seven or eight pounds of turpentine annually for forty or fifty years.

The *Carpathian*, or *Hungary balsam*, is obtained from the stone pine in Hungary and the Tyrol, either by breaking off the twigs of the tree, and collecting in a glass the fine resin that exudes; or by boiling the ends of the fresh boughs in water, when the balsam rises to the top. The former method yields by far the best. This is a whitish, pellucid, and very fluid turpentine, which does not harden by keeping.

The *Canada balsam* is a transparent whitish juice, of the consistence of Copaiva balsam, and of a very fragrant smell and bitterish taste, obtained from the balm of Gilead fir, and imported from Canada: but the mode of collection is not well known.

To return to the various operations performed with the common turpentine, which as above mentioned is obtained in two degrees of liquidity, the most fluid being called properly turpentine, and the least fluid having the name of *barras* or *galipot* in the south of France, whence it is produced.

The turpentine contains a number of impurities entangled in its substance, from which it is purified by two methods. One of them is to inclose it in a cask perforated at bottom, and by exposure to a hot sun it becomes so fluid as to filter through, which gives the finest and most valued turpentine. The other method is to heat it moderately in a large copper, till it is quite liquid, and then to filter it through a strainer made of rows of straws laid close to each other. This gives it a golden colour.

The harder turpentine, or *Barras*, is also purified in the latter mode, but instead of being merely liquefied in the copper heat is continued for some time, till part of the essential oil is so far dissipated, that a little of it cooled on a piece of wood may be crushed to powder by the fingers. It is then strained through straw while hot, and the pure resin on cooling hardens into a yellow opake mass, which is called *Brai-sec*, or *Rose*. This is sometimes sold as *Burgundy pitch*, which however appears to be properly the product of another species of pine, as we shall presently mention. This opake yellow brown resin is rendered transparent, and of a fine clear amber yellow, by mixing it when melted with about an eighth of boiling water, and stirring it incessantly for a considerable time till the water is cold. The resin is then cast into moulds and cooled.

Essential Oil of Turpentine.

This valuable oil is prepared largely, both in the countries where the turpentine is extracted, and from turpentine imported into this country. The process is the following: an alembic, with a worm and cooler, is used, precisely of the same construction as what is employed for the distillation of spirits; this is filled with turpentine and water in due proportions, and the volatile part after distillation is found to consist of oil of turpentine swimming on water. This oil is perfectly limpid and colourless, has a very strong smell, a bitterish taste, is extremely inflammable, and in short possesses all the properties of the other essenial oils. It is employed in immense quantities in a variety of varnishes and similar preparations; but for the finer purposes, such (for example) as that of dissolving gum copal, it is necessary to rectify it by a second distillation with water, in a still, using a very gentle heat, and keeping apart the first product which is the best. From 250 pounds of good turpentine, about 60 pounds of oil may be obtained.

Common Rosin, Yellow Rosin, Colophony.

The residue from the distillation of the oil of turpentine, is an opake, brittle, light yellow mass, much less clammy and cohesive than inspissated turpentine, and requiring a greater heat for fusion: it is the common resin or rosin of the shops. It is also called by the French *Brai-sec*, as well as the boiled *galipot*, or harder turpentine; but the latter is more esteemed, as it still contains a good deal of essential oil, and is fitter for most of the purposes for which the terebinthinate substances are employed. When common rosin is boiled with water for a time, it becomes yellow and transparent, and is then the rosin used by musicians to rub the bows and strings of violins. When common rosin is kept in fusion for a considerable time, it becomes of a browner colour, is still harder, and less adhesive to the fingers when cold, and is then called *Black rosin*, or *Colophony*, and this is the ultimate point to which the inspissation of turpentine is carried.

There are other less important varieties in the products of common turpentine, which it is needless to describe.

A very fine essential oil is prepared in some parts of Germany, by distillation of the green tops and cones of the stone pine (*Pinus cembra*) which is known in medicine by the name of *Oleum templinum*, or properly, *Krumholzoel*, and is an approved remedy for a number of complaints It is somewhat greenish, or sometimes of a golden yellow, very fragrant and aromatic.

The true *Burgundy pitch* is a brittle, opake, light yellow, or sometimes reddish brown resin, of a fine terebinthinate smell and taste, which is chiefly imported from Saxony, and is collected in quantity in the neighbourhood of Neufchatel from the Norway spruce fir.

Incisions are made in the usual manner, and the surface of the wood laid bare, which is soon covered with a turpentine, less liquid than the common sort, and which, therefore, soon concretes on the incision without flowing down. This is picked off, and when a sufficient quantity is collected, it is put with water into large boilers, melted, and then strained under a press, through close cloths into barrels, in which it is transported for sale. Burgundy pitch is of such a consistence that it will barely soften by the heat of the human body, and is much used in plasters. It is often adulterated (as is supposed) by a mixture of rosin and turpentine.

Burgundy pitch is also obtained from the larch.

The substance commonly called *Frankincense* (*Thus*,) is a solid brittle resin, in small roundish masses, of a brownish yellow on the outside, and white internally. It possesses the common properties of the turpentines, and has a very pleasant smell when burned. It is supposed to exude spontaneously (and not by incision) from the Norway spruce, and to undergo no preparation.

All the terebinthinate substances above described are either nearly in the state in

which they exude from the tree, or are prepared by heat with the intervention of a suitable apparatus.

There is another product more important than any other, especially in a maritime country, which is prepared by a kind of distillation *per descensum*, with no inconsiderable skill, but often without any other apparatus than the substance itself that yields it, and this is *common tar*.

Tar.—Goudron, *French*, is a thick dark brown or black resinous adhesive juice, melted by fire from the wood and roots of old pine and fir trees, during which process the wood itself is reduced to charcoal.

Every part of the tree which is at all resinous, is fit for obtaining tar, but in particular it is the red wood and the hard roots that yield the greatest quantity and the best. As the wood is entirely charred in the process, all the sap and other volatile parts must be expelled, most of which mixes with the turpentine, which sweats out and constitutes tar, and hence this substance must considerably vary, in the quality and proportion of resin, empyreumatic oil and acid which it contains, according to the age of the tree, the soil on which it grows, the part selcted, the management of the heat, &c.

The extraction of tar from pine-trees is very ancient, being described by Theophrastus, Dioscorides, and other old authors, and the method of proceeding was extremely simple. Very large stacks were made of billets of pine, and covered with turf, to prevent the volatile parts from being dissipated. They were then kindled, and suffered to burn with a low smothered flame, during which the tar melted out by the heat, flowed to the bottom of the stack, and ran out by a small channel cut for the purpose. A very large proportion of the tar actually made in Norway, and the other Baltic countries, is prepared in this rude manner. The stacks are built upon the slope of a hill, covered with moss and turf, kindled, and the tar that oozes out is collected and put into barrels.

But a more economical and scientific method is practised in France, and Switzerland, which is to heat the wood in large brick ovens built for the purpose, whereby the wood is charred much more equally, and the tar is of a more uniform, and probably a better quality. The following is the method of proceeding in the Valais: the pines are previously felled in the preceding year, that the wood may be dry enough when wanted, and the outer bark and twigs being stripped off, the rest of the tree is cut up into billets of tolerably equal size. The oven is built of stone or brick, in the form of an egg standing on its small end. The floor is made either of a single stone scooped out into a hollow, or of several joined very accurately. On one side of it, about five inches above the lowest part, is a hole in which a large gun barrel is thrust, which serves to convey off the liquid tar as it collects. A large iron grate is laid at the bottom of the oven. The largest of these ovens are about ten feet high, and five or six feet in the largest diameter. To charge the oven, bundles of these billets are thrown in, and the wood spread as evenly as possible, filling the interstices with the chips, till it nearly reaches the top. The whole is then covered with a layer of chips, and the top of the furnace is closed with flat stones; heaped one upon the other, gradually lessening the opening, and forming a kind of vaulted chimney, the mouth of which is four or five inches across. The dry chips at top of the furnace are then set on fire, and the heat spreads downwards till the whole of the charge is judged to be sufficiently kindled. The chimney is then entirely closed with a large stone, and wet earth is heaped on the stones at top, and thrown on wherever the smoke bursts out too strongly. The melting now begins, the tar falls down to the bottom, fills the hollow of the floor, (which last detains any bits of wood and other impurities) and runs off through the gun barrel into casks placed to receive it. Some skill is required in managing the fire, which must sometimes be refreshed by letting in a small draught of air through small holes left for the purpose in the sides of the kiln. When the process is over, the wood is found completely charred, and is taken out, and the oven after being cleared out is again filled. It is found that the red wood and knots, which are the richest in the resin, will yield about a fourth of their weight of tar, but the general average of product is about 10 or 12 per cent. of the weight of the whole charge. After each process, a quantity of *lamp-black* is collected beneath the stones, that form the vault of the temporary chimney.

This latter substance is also another product from the pine, and in the large way is procured by a different process, as described under the article *Carbon*.

A substance somewhat resembling tar, called *Brai-gras*, and much used in the French ports for careening ships, is made in the following way. The oven above described is charged with alternate layers of chips of green wood, and billets of dry, and all the refuse matter of turpen-

tine, the straw through which it is strained, and the like. Over the whole is laid a stratum of *brai-sec*, or rosin, and the gun-barrel pipe is stopped up, and not tapped till the whole of the wood is reduced to charcoal. The vault of the oven is also covered more carefully after the charge is sufficiently kindled, and the whole process is carried on more slowly. The heat of the fire melts the rosin at top, which mixes with the resinous sap, and the whole collects into a dark resinous liquid at the bottom. When sufficiently cooled, it is drawn off and barrelled. The *brai-gras* is of an intermediate consistence, between tar and rosin.

Pitch.—The substance called pitch in this country, is simply tar, inspissated to the requisite degree by boiling.

It does not appear, however, that the French have this precise preparation, as the substance called *Poix* is made either by melting together due proportions of rosin with tar, or else by filling a kind of oven with various refuse matters from the turpentine, such as the straw through which it has strained, together with the coarse strainings, chips of bark, soaked in turpentine, the broken earth of the moulds in which the resin collects, &c kindling it till all the resin falls down into a reservoir, and continuing the heat till it is sufficiently inspissated. This forms a hard black mass called *Poix dure*, or *Pegle*.

The pitch made in England by boiling down tar to the proper consistence, is now performed near London, and in some other parts, in a still with a worm-tub attached to it, in order to collect the valuable volatile products of the tar. The process is the following: the barrels of tar being of various consistence, their contents are first emptied into a copper, and gently heated and well stirred, to render them thin and uniform. The tar is then laded into the still, passing through a sieve to keep out chips of wood and other impurities.

When the still is properly luted, the fire is kindled and kept up very moderate for three hours, as the tar is very apt to boil up in the early part of the process. The first product that distils over is principally a brown acid water, mixed however with a good deal of oil. As the process advances, and the heat is increased, the quantity of acid lessens, and that of oil increases, and towards the end of the distillation the product is chiefly oil. The length of the process varies according to the quality and hardness of the pitch required. In general, a still that holds about 600 gallons will work 18 or 20 barrels of tar in 8 hours, the produce of which will be about 10 barrels of pitch (or 22 cwt.) 176 gallons of oil; and about 40 gallons of acid. The pitch remains in the still for 12 hours, after which it is barrelled, and hardens as it cools.

The oil and acid water, which distil over do not mix, so that they may be easily separated by decantation. The oil is a brownish inferior kind of oil of turpentine, which is very useful in painting ships and other coarse out-door work. The acid is a very strong brownish empyreumatic acid, which appears very closely to resemble the pyroligneous acid obtained from the distillation of wood, during its conversion to charcoal, and is now employed pretty largely in composing several of the mordants in calico printing.

TURPENTINE (*Chio.*)—This is a very fragrant resin, obtained sparingly by incision of the bark of the *Pistacia Terebinthus*, a small tree growing in the isle of Chio, and in many other parts of the Levant.

It is a thick and tenacious substance, whitish, nearly transparent, highly fragrant, and almost tasteless. It is seldom found genuine, the common Chio turpentine of the shops being largely adulterated with the finer sorts of the pine turpentines

TUTENAG, an alloy of copper.—This name is given in India to the semi-metal zinc. It is sometimes applied to denote a white metallic compound brought from China, called also Chinese copper, the art of making which is not known in Europe. It is very tough, strong, malleable, may be easily cast, hammered, and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is. Three ingredients of this compound may be discovered by analysis; namely, copper, zinc, and iron.

Some of the Chinese white copper is said to be merely copper and arsenic.

Mr. Engestrom, in the Memoirs of Stockholm for the year 1775, quoted by Kirwan, has given us an analysis of a tutenag ore from China. It was of a white colour, interspersed with red streaks of oxide of iron, and so brittle as to be easily broken betwixt the fingers. In the dry way it exhibited the same appearances as zinc spar, except that it lost no part of its weight. It was soluble in the mineral acids, particularly with the assistance of heat, and with the sulphuric, afforded sulphates both of zinc and iron. The quantity of carbonic acid was so small as to be absorbed by solution. It contained in various specimens from 60 to 90 per cent. of zinc; the remainder was iron, and a

small proportion of clay. This variety of calciform ores, which was mixed with a notable proportion of iron, was also discovered in Germany by Mr. Bindheim, who found it to consist of zinc, a little iron, and silex.—4 *Berl. Schrift.* 400.

TUTTY.—A metallic substance, various in its composition and properties, which nevertheless appear to depend on the presence of zinc. The better sorts of tutty, according to Neumann, are in semi-cylindrical concave pieces, like the bark of a tree; ponderous and somewhat sonorous; moderately compact, and generally not easy to break; of an ash or mouse-gray colour, often with yellow or green variegations; pretty smooth on the inside, full of cavities or protuberances on the outside. The entire, compact, gray pieces are preferred; the broken, powdery, crumbly, yellow, or reddish, rejected. Boecler relates, that Tutty has a sharp taste, but no such taste is perceptible in the English.

Wiegleb affirms, that the matter which in the fusion of brass is deposited over the melted metal, is called tutty; but Neumann made various unsuccessful inquiries relative to its origin, and the place where it may be produced. That it is not produced at Goslar, or Schneeberg, or at any of the considerable founderies of brass, bronze, bell-metal, &c. in Germany, Holland, France, Italy, and England, he affirms from his own experience. He therefore concludes, that it is an artificial production, expressly made up of the oxide of zinc with clay and other matters.

TYPE METAL.—The basis of type metal for printers is lead, and the principal article used in communicating hardness is antimony, to which copper and brass in various proportions are added. The properties of good type metal are, that it should run freely into the mould, and possess hardness without being excessively brittle. The smaller letters are made of a harder composition than those of a larger size. It does not appear, that our type founders are in possession of a good composition for this purpose. The principal defect of their composition appears to be, that the metals do not uniformly unite. In a piece of casting performed at one of our principal founderies, the thickness of which was two inches, we found one side hard and brittle when scraped, and the other side, consisting of nearly half the piece, was soft like lead. The transition from soft to hard was sudden, not gradual. If a parcel of letter of the same size and casting be examined, some of them are brittle and hard, and resist the knife, but others may be bent and cut into shavings. It may easily be imagined, that the duration and neatness of these types must considerably vary. We have been informed, but do not know the fact, that the types cast in Scotland are harder and more uniform in their qualities.

TYPE-FOUNDERY. See FOUNDERY.

U.

ULTRA-MARINE. *Outremère*, French. —This precious colour, so remarkable for its beauty and durability, is a pure deep sky blue. It is capable of bearing a low red heat without injury, and it is not sensibly impaired by the action of the air and weather. It is the colouring matter of the mineral already described under the name Lapis Lazuli, and appears, according to an analysis by Klaproth, to consist of little else than oxide of iron. The method in which this pigment is separated from the earthy parts of the above mineral is as follows. Let the lapis lazuli be heated just to redness, and then suddenly quenched in cold water, and let this be repeated two or three times till the stone becomes almost friable; then let it be ground down with a few drops of water in a clean iron mortar, or still better, in an agate one, till it is reduced to a perfectly impalpable powder. Then take one pint of linseed oil, warm it over the fire in a clean vessel, and add one pound of bees-wax, one pound of turpentine, half a pound of rosin, and half a pound of gum mastich: keep the ingredients over the fire, with constant stirring till they are melted and thoroughly incorporated together; the result will be a tenacious adhesive mass. Of this take any quantity, 6 oz. for example, melt it and pour it into a warm clean mortar; then sprinkle upon it 3 oz of pulverized lapis lazuli, and incorporate it thoroughly by long beating with the pestle; this being done, pour in some water, and again work it about in the same manner as before: in a short time the water will become charged with the blue colouring matter; it must then be poured into a clean tall glass, and replaced by fresh,

proceeding in this manner till the paste will give out no more colour on the addition of fresh water. By standing a few days, the colour will subside from the water in which it was suspended; the clear fluid being then decanted off, and the rest got rid of by evaporation, there will remain a deep blue powder which is ultramarine. See COLOUR-MAKING.

UMBER.—There are two kinds of umber, the one called *Cologne Umber*, is a variety of peat or of earthy brown coal. There are large beds of it wrought in the neighbourhood of Cologne, principally as an article of fuel; a pretty considerable quantity is also imported into Holland, where it is used in the manufacture, or more properly in the adulteration of snuff, for which purpose it appears to be better than the common peat of the country; a still smaller quantity is consumed by the paint-makers.

The colour of this vegetable umber is a warm somewhat pinkish brown, and is an useful ingredient to the painter in water colours.

The second kind of umber goes by the name of *Turkish umber*, and appears to be a variety of the iron ore called brown ironstone ochre. A specimen from Cyprus was analysed by Klaproth, and afforded him,

48	Oxide of iron
20	Oxide of manganese
13	Silex
5	Alumine
14	Water
100	

See COLOURS.

UNDERSHOT-MILLS. See MECHANICS.

URAN-GLIMMER.—An ore of uranium, formerly called *green mica*, and by Werner *chalcolite*. See the following article.

URANITE, or URANIUM.—A new metallic substance discovered by the celebrated Klaproth in the mineral called *Pech blende*. In this it is in the state of sulphuret. But it likewise occurs as an oxide in the green mica, or uran-glimmer, and in the uran-ochre.

The uran-glimmer is in thin leaves, or small quadrangular tables; of an emerald green, lemon-yellow, and sometimes silver-white colour; more or less transparent; soft and easily broken; specific gravity from 2.19 to 3.1. This is nearly pure oxide of uranium, but sometimes contaminated with a little copper, which appears to give it a green colour. The reverend Mr. Gregor found oxide of lead, lime, and silex, in some Cornish specimens.

The uran-ochre is generally an incrustation or efflorescence, of a light yellow colour, sometimes tinged green, brown, or red. Specific gravity 3.2. This too is nearly pure oxide of uranium, mixed with a little oxide of iron when of a red or green colour.

By treating the ores of the metal with the nitric or nitromuriatic acid, the oxide will be dissolved; and may be precipitated by the addition of a caustic alkali. It is insoluble in water, and of a yellow colour; but a strong heat renders it of a brownish gray.

To obtain it pure, the ore should be treated with nitric acid, the solution evaporated to dryness, and the residuum heated, so as to render any iron it may contain insoluble. This being treated with distilled water, ammonia is to be poured into the solution, and digested with it for some time, which will precipitate the uranium and retain the copper. The precipitate, well washed with ammonia, is to be dissolved in nitric acid, and crystallized. The green crystals, dried on blotting paper, are to be dissolved in water, and recrystallized, so as to get rid of the lime. Lastly, the nitrate, being exposed to a red heat, will be converted into the yellow oxide of uranium.

It is very difficult of reduction. Fifty grains, after being ignited, were formed into a ball with wax, and exposed, in a well-closed charcoal crucible, to the most vehement heat of a porcelain furnace, the intensity of which gave 170° on Wedgewood's pyrometer. Thus a metallic button was obtained, weighing 28 grains, of a dark gray colour, hard, firmly cohering, fine-grained, of very minute pores, and externally glittering. On filing it, or rubbing it with another hard body, the metallic lustre has an iron gray colour; but in less perfect assays it verges to a brown. Its specific gravity was 8.1. Bucholz, however, obtained it as high as 9.0.

When heated to redness in an open vessel, it undergoes a species of combustion, and is soon converted into a grayish black powder, containing about 5 per cent. of oxigen. According to Bucholz, it forms six distinct oxides, in the following order of succession, as marked by their colours; grayish black, dark gray inclining to violet, greenish brown, grayish green, orange, and lemon-yellow.

The oxide is soluble in dilute sulphuric acid gently heated, and affords lemon-coloured prismatic crystals. Its solution in muriatic acid, in which it is but imper-

fectly soluble, affords yellowish green rhomboidal tablets. Phosphoric acid dissolves it, but after some time the phosphate, falls down in a flocculent form, and of a pale yellow colour.

It combines with vitrifiable substances, and gives them a brown or green colour. On porcelain, with the usual flux, it produces an orange.

URANOCHE.—An ore of uranium, containing this metal in the oxided state See the preceding article.

USQUEBAUGH. See DISTILLED SPIRITS.

V.

VALVE. The use of valves has already been mentioned when treating of sundry engines for raising water: we shall here add a few remarks on the different kinds of valves. There are three kinds of valves, the *clack-valve*, the *butterfly-valve*, and the *button* or *tail-valve*.

The Clack-Valve.

Is of all others the most obvious and common. It consists merely of a leather flap covering the aperture, and having a piece of metal on the upper side, both to strengthen and to make it heavier, that it may shut of itself. Sometimes the hinge is of metal. The hinge being liable to be worn by such incessant motion, and as it is troublesome, especially in deep mines, and under water, to undo the joint of the pump, in order to put in a new valve, it is frequently annexed to a box like a piston, made a little conical on the outside, and dropt into a conical seat, made for it in the pipe, where it sticks fast; and to draw it up again, there is a handle like that of a basket, fixed to it, which can be laid hold of by a long grappling-iron. The only defect of this valve, is, that by opening very wide, when pushed up by the stream of water, it allows a good deal to go back during its shutting again.

The Butterfly-valve.

Is free from most of these inconveniences, and seems to be the most perfect of the clack-valves. It consists of two semicircular flaps revolving round their diameters, which are fixed to a bar placed across the opening through the piston.—Some engineers make their great valves of a pyramidal form, consisting of four clacks, whose hinges are in the circumference of the watery-way, and which meet with their points in the middle, and are supported by four ribs, which rise up from the sides, and unite in the middle. This is a most excellent form, affording a more spacious water-way, and shutting very readily.

The Button, or Tail-Valve.

It consists of a plate of metal turned conical on the edge, so as exactly to fit the conical cavity of its box. A tail projects from the under side, which passes through a cross bar in the bottom of the box, and has a little knob at the end, to hinder the valve from rising too high.—This valve, when nicely made, is unexceptionable. It has great strength, and is therefore proper for all severe strains; and it may be perfectly tight by grinding. Accordingly, it is used in all cases where tightness is of indispensable consequence. It is most durable, and the only kind that will do for passages where steam or hot water, is to pass through.

In addition to the valves mentioned, there are other shapes, as pyramids, &c. The pyramid valve consists of four triangular flaps, which represents the sides of the pyramid, and moves upon hinges fixed on the circumference of the opening. Their vertices meet in the middle of the opening, and are supported by four bars which meet in the centre. The operation of all kinds of valves, is on the same principle, viz. either to admit the entrance of a fluid and prevent its return, or permit it to escape, and prevent its re-entrance.

VALVE OF SAFETY. The steam valves, of steam engines, as they are called, which are adjusted to certain weights of pressure, in order to prevent accidents, are called valves of safety. See STEAM ENGINE. There are also valves of safety made use of, in several chemical operations.

VALONEA is the husks of the acorn, generally mixed with that fruit; though this diminishes its value. It is brought to us from Italy and the Levant, and used as a dyeing ingredient.

VANILLA in commerce, is the pod of a species of epidendrum, which is brought to us entire, and with the seeds in it, being usually about five or six inches long, and half an inch broad, and containing an al-

most innumerable quantity of minute and glossy black seeds.

The vanilla plant is a native of Mexico, where, like the ivy, it grows to the trees it meets with, covers them almost entirely, and raises itself by their aid.

This plant produces but one crop of fruit in a year, which is commonly ripe towards the end of September, or rather fit for gathering; for it is not suffered to remain till perfectly mature, because it is then not so fit for use. The pods grow in pairs, are generally the thickness of a child's finger, green at first then yellowish, and turning to a brownish cast, when completely ripe. When it is about half changed yellow, it is esteemed better for gathering, than when changed to a brown colour, at which time it splits and discloses its seeds.

The aromatic odour that is peculiar to them, cannot be obtained without preparation. This preparation consists in threading several pods, and dipping them for a moment in a caldron of boiling water to whiten them. They are afterwards suspended in a place exposed to the open air, and to the rays of the sun. A thick and plentiful liquor then distils from their extremity, the exit of which is facilitated by a slight pressure, repeated two or three times in the course of the day. In order to retard the drying, which ought to go on slowly, they are rubbed over at several different times with oil, which preserves their suppleness, and keeps them from insects. They are also tied round with a cotton thread, to prevent them from opening. When they are sufficiently dried they are rubbed with the hands, anointed with oil, and put into a pot that is varnished, in order to keep them fresh. In some parts after gathering as before mentioned, they scald the pods in the following liquor: viz. a brine is made with salt and water, strong enough to bear an egg. To this are added a fourth part of urine, and a small quantity of quicklime: these are boiled together for half an hour and then taken off. The vanillas are put into this liquor, until thoroughly scalded, then taken out and dried in the shade. When fit for market they are put up, from 50 to 150 in little bags.

Vanilla is used in the manufacture of chocolate, likewise to perfume snuff and other substances.

VAPOUR. The elastic fluids, or subtile invisible matters, which fly off from bodies subjected to chemical operations or otherwise, are called vapours. But accurate chemical writers confine this appellation to such exhalations, only as may be condensed into the fluid state by cold, in contra-distinction, to the aerial fluids, or gasses, of which scarcely any are so convertible, by any means in our power.

VARIATION OF THE COMPASS. See MAGNETISM.

VARNISHING, and LACQUERING, *the Art of*—The number of formulæ for the preparation of varnishes is very extensive, and therefore, without troubling our readers with a great number of superfluous receipts, we shall enumerate those which have been approved, at the same time give some general directions for facilitating the processes.

A varnish, in the most extensive application of the term, is any fluid, which when spread thin upon a solid substance adheres to it, and, becoming dry, forms upon its surface a shining coating impervious to the air and to moisture.

In treating of this subject the most convenient method of arranging it, will be according to the nature of the menstrua from which the different varnishes derive their fluidity. These menstrua are three in number, namely alcohol, essential oil, and fat oil.

The solid substances which by solution in the above menstrua, compose the body of the different varnishes are the following.

1. *Benzoin.* This substance is used in compound alcoholic varnishes, chiefly on account of its fragrant odour: by itself, it forms a tenacious but soft varnish, which requires the addition of some of the harder resins.

2. *Lac.* This is one of the most useful ingredients in alcoholic varnishes: it forms a body of great toughness and hardness: the only objection to it, is its colour, which is a brownish red.

3. *Mastich.* This is a resin of prime importance to the varnisher; if well selected, it has scarcely any colour, and possesses both toughness and hardness in a very considerable degree.

4. *Anime.* This resin is employed in some compound alcoholic varnishes, chiefly on account of its agreeable odour.

5. *Elemi.* Of this resin there are two sorts, the Ethiopian and South American. The former is greatly preferable to the latter; it is of a solid but tough consistence, a greenish colour, and possesses an odour resembling that of fennel; it communicates to the compound varnishes great toughness and durability.

6. *Sandarach.* This resin communicates remarkable splendour to alcoholic varnishes, but on account of its softness requires to be mixed with the harder and tougher resins.

7. *Turpentine.* Almost all the different varieties of turpentine are employed by the varnisher: they afford glossiness and body at small expense, but require the admixture of some of the harder resins.

8. *Gamboge.* 9. *Dragon's blood.* These are never employed by themselves, but are used in small proportions, for the purpose of colouring compound varnishes, especially those used in lacquering.

10. *Copal.* This valuable substance is employed in all the three kinds of varnish, to which it communicates an uncommon degree of hardness.

11. *Amber.* This is also a very valuable ingredient, but its application is principally confined to the coloured and opake oil varnishes.

12. *Asphaltum.* This bitumen is extensively used in the best black oil varnishes.

13. *Caoutchouc.* This substance is used only in the oil varnish with which balloons are covered.

Preparation of Alcoholic Varnishes.

Alcoholic varnishes are prepared with less trouble than others, they are easily applied, they soon dry, and are entirely free from any disagreeable odour; on this account they are in very general estimation. They are, however, very liable to crack, or scale off, and are incapable of resisting blows or long continued friction.

The composition of these varnishes, though upon the whole sufficiently simple, requires a few precautions which we shall proceed to mention. In the *first* place, care should be taken not to add more resin than the spirit can take up; for most resins, however homogeneous they may appear to be, consist of parts unequally soluble in alcohol; the consequences of a superfluity of resin therefore will be, that the most soluble parts alone will be taken up, and the resulting varnish will be found to be much softer and less durable than if only such a quantity of resin was added as just sufficed to saturate the alcohol. Indeed the very best way of proceeding is, to add the resin by small portions at a time, taking care not to add a fresh quantity till the whole of the preceding is taken up.

Secondly, a mixture of two or more resins is soluble in a less quantity of alcohol than would have been required for the solution of each separately. This is particularly the case with those compounds into which copal or sandarach enter; these substances, especially the former, being but very sparingly soluble by themselves in alcohol.

Thirdly, much depends upon the purity of the alcohol. If diluted to a certain degree with water, it is incapable of acting even on the softest resins; and for copal varnishes the highest possible degree of rectification is absolutely essential. The addition of camphor singularly facilitates the solution of copal, and the more intractable resins; but if used in too great a proportion, it makes the varnish mealy, and diminishes its tenacity.

Fourthly, during the solution of the resins, it is expedient that they should expose as large a surface as possible to the action of the spirit; for it not unfrequently happens, especially when heat is applied, that the resins run together into a tough mass, after which their solution goes on very slowly: this inconvenience may be obviated by mixing the resins with rather coarsely pounded glass.

The following are some of the most approved receipts for alcoholic varnishes.

1. Take of clean mastich 6 ounces; and of sandarach 3 ounces, and reduce the mixture to fine powder in a clean Wedgwood mortar: to this add 4 ounces of coarsely pounded glass, and pour the mixture into a three pint flask containing a quart of highly rectified alcohol: stop the flask loosely with a cork, and let the ingredients digest together in a warm room for three days, shaking the mixture frequently in the interval. Then melt 3 ounces of very clear Venice turpentine, by putting it into a cup set in hot water, and as soon as it is perfectly liquefied, pour it into the alcoholic solution, also previously warmed, and then digest the whole in hot water for two hours; stirring it up frequently with a rod of glass, or a stick of white wood. When the digestion is finished let the flask stand quiet for about a week in a warm room, and after that strain the varnish into a bottle through a little cotton wool.

2. Take of copal that has been liquefied, and afterwards very finely pounded, 3 ounces, of clean mastich 3 ounces, of gum sandarach 6 ounces, and of pounded glass 4 ounces: mix the ingredients with a quart of alcohol and digest them as already directed: then add $2\frac{1}{2}$ ounces of clear turpentine.

This is a strong and durable varnish, which may be applied to chairs and other articles of furniture.

3. Take of sandarach 4 ounces, of seed lac 2 ounces, of mastich 2 ounces, and of elemi 1 ounce; digest the whole in a quart of alcohol moderately warm, and when

the solution is complete, add 2 ounces of Venice turpentine. This forms a good varnish for violins and other musical instruments.

4. Take of seed lac 8 ounces, and digest it for three or four days in a warm place with a quart of alcohol; when the solution is complete, strain it through flannel to separate the impurities, and the clarified liquor is the common lac varnish.

5. Take of mastich half an ounce, of white frankincense a quarter of an ounce, of sandarach half an ounce, of benzoin half an ounce, and dissolve the ingredients in a pint of highly rectified alcohol: a colourless varnish is thus formed, which is employed for defending the silvering of clock faces, of barometer scales, and other similar articles, from the action of the air.

6. Take of sandarach 6 ounces, of elemi 4 ounces, of anime 1 ounce; pound the whole together, and then add 4 ounces of coarsely pulverized glass; infuse the mixture in a quart of rectified alcohol, and add at intervals as the solution goes on half an ounce of camphor. The result is a very good colourless varnish for boxes of *papier maché*, and similar articles.

7. A similar varnish to the above, but somewhat coarser, is composed of white frankincense 6 ounces, anime and elemi of each 2 ounces, pounded glass 4 ounces, and a quart of alcohol.

The following account of an excellent colourless copal varnish is by Mr. Lenormand.

"All copal is not fit for making this varnish; it must therefore be selected with care, and the following method will show when it is good. Take each piece of copal separately, and let fall on it a single drop of very pure essential oil of rosemary, not altered by keeping. Those pieces on which the oil makes a certain impression, that is to say, which soften at the part that imbibes the oil, are good, and should be reserved for making varnish. The other ought to be rejected.

Powder the pieces of copal thus selected, sift the powder through a very fine hair sieve, and put it into a glass, on the bottom of which it must not lie more than a finger's breadth thick. On it, pour essence of rosemary to a similar height, stir the whole together with a stick for a few minutes, the copal will dissolve into a viscous substance, and the whole will form a very thick fluid. Let it stand for a couple of hours, after which pour on gently two or three drops of very pure alcohol, which you will distribute over the oily mass by inclining the glass in different directions with a very gentle motion. In this way, you will effect their incorporation. Repeat this operation, little by little, till the varnish is reduced to a proper degree of fluidity. Remember, the first drops of alcohol are the most difficult, and require the longest time to incorporate; and that the difficulty diminishes as each successive addition is incorporated, or as the mass approaches the state of saturation.

When the varnish has attained the suitable degree of fluidity, it is to be suffered to stand a few days; and when it has become very clear, the varnish is to be decanted off.

The magma that remains at the bottom may still be rendered useful, by pouring on alcohol in the manner directed above; but care must be taken, to add very little at a time.

This varnish is made without heat, is very clear and colourless, may be applied with equal success on pasteboard, wood, and metals, and may be worked and polished with ease, indeed better than any known varnish. It may be used on paintings, and singularly heightens their beauty.

Essential Oil Varnishes.

The high price of most of the essential oils is such as to preclude the varnisher from the use of them; oil of lavender is occasionally employed, but the usual menstruum is oil of turpentine. The purity of this latter fluid is of the utmost importance; that which is commonly sold at the oil and colour shops, though sufficiently pure for oil painting, will very rarely answer the purpose of the varnisher, who if he wishes to save himself from much mortification and disappointment will apply for this article to chemists and apothecaries, where it may be procured (provided it be particularly so ordered,) in the greatest purity.

Varnishes with oil of turpentine and the resins are somewhat softer, but considerably tougher than those prepared with alcohol; hence they are not so liable to crack and scale off. They are principally used for varnishing oil paintings, for mixing up colours with, and for lacquering. A composition applicable to the first of these purposes is the following.

8. Take of pure and washed mastich 12 ounces, and of pounded glass five ounces, infuse the mixture in a quart of pure oil of turpentine, adding at intervals half an ounce of camphor in small pieces: when the mastich is dissolved add to the warmed fluid an ounce and a half of clear turpentine previously melted, and stir the mixture together till it is thoroughly incorporated.

Several of the copal varnishes may be also arranged under this section, especially those that are best fitted for varnishing articles of wood and pasteboard. Several of these have been already described under the article COPAL, to which we refer the reader. To those may be added the following very simple and very efficacious one.

9 Take from 3 to 4 ounces of copal, that has previously been liquefied in as gentle a heat as possible, and 20 ounce measures of the purest oil of turpentine; put this latter in a mattrass set in boiling water, and add the pulverized copal in small quantities at a time, in proportion as it is dissolved. If the materials are good, and the process well conducted, somewhat more than 3 ounces of copal will be taken up, and the liquid will be a little cloudy: by standing for a few days it will become clear, and should then be strained through cotton. This is a thick varnish, and will generally require to be diluted with a little warm oil of turpentine before it can be used: it forms a very hard and durable glazing, which will dry in summer in the space of two or three days, or in a less time if put into a warm stove.

Of Fat Oil Varnishes.

These are tougher and less liable to crack than the preceding, and by exposure to a proper degree of heat, may be made to acquire a very great hardness: they are, however, without the assistance of a stove, very long in drying, during which they give out an extremely disagreeable odour: they are also, for the most part, highly coloured, and are therefore seldom used by themselves, but mixed up with some opake colour. The materials employed in the composition of these varnishes, with the exception of mere colouring substances, are the following:—copal, amber, asphaltum, drying oil, and oil of turpentine.

The most colourless of the fat varnishes is thus prepared.

10. Take of copal liquefied, according to Tingry's method, and finely pulverised 4 ounces, of drying linseed oil and oil of turpentine, each 10 ounces; put the whole into a mattrass, and apply a very gentle heat till the copal is dissolved: this being done, let the varnish stand for a few days to clear, and afterwards strain it through cotton. This forms a solid and nearly colourless glazing, and dries easily at the common temperature.

11. Take of picked copal 16 ounces, and melt it in a clean iron pot with as gentle a heat as possible; when its fusion is complete, pour in 3 ounces of drying linseed oil, boiling hot, and incorporate the ingredients by stirring; then remove it from the fire, and while it is yet warm, pour in a pint of oil of turpentine, also warm; strain the varnish before it gets cold, through a piece of linen, and bottle it. The older it is before being used the better. This is a very valuable varnish, though higher coloured than the preceding; when dried carefully in a stove it becomes very hard. Amber varnish is reckoned harder than copal varnish, on which account it is preferred for some works; it has the disadvantage, however, of being much deeper coloured. To prepare this varnish,

12. Take of amber coarsely pounded 16 ounces, and melt it in a clean iron pot, then add to it 2 ounces of melted lac and 10 ounces of drying oil boiling hot; incorporate the whole accurately by stirring, then remove it from the fire, and add a pint of warm oil of turpentine.

The beautiful black varnish used by the coach-makers is thus prepared.

13. Take of amber 16 ounces, and melt it in a clean iron pot, then add to it half a pint of drying linseed oil boiling hot, and 3 ounces of rosin, and the same quantity of asphaltum, each in fine powder, stir the materials together till they are thoroughly melted and incorporated; then remove the varnish from the fire, and add to it a pint of warm oil of turpentine.

The above oil varnishes are intended to dry to a very hard consistence; those, however, that are employed for making silk, and linen, water, and air tight, are required to be tough, without any degree of hardness. A varnish of this kind, which was first applied to balloons, is thus composed.

Recipe for an elastic and permanent Varnish for Hats or Helmets of Felt, Gaiters, or other Parts of Dress in Leather, as Boots and Shoes, and which may be also employed with success in varnishing Cloth and Linen.

First Operation.—It is necessary, in the first place, to free the hats, or other articles of felt, from all the gum which they may contain. This may be easily effected by washing them in warm water, and afterwards pressing them. Before they are perfectly dry, they must be placed on moulds in order that they may be preserved in their proper shape, and be without wrinkles—a very essential requisite. New leather, as well as old, must

be scraped in order to clear its superficies from the wax or grease, with which it is impregnated. Colophony, or resin in powder, laid upon a coarse brush, will remove the grease perfectly well.

Second Operation.—All felt hats have a kind of down or nap, of which they must be cleared, when dry, by means of pumice stone; and every part of the hat where the varnish is to be applied must be smoothed in this manner. Leather must be smoothed in the same manner also, to remove all inequalities, and even the marks of the scraper.

The same method must be pursued with cloths or linens.

Third Operation.—The down being removed in the manner above described, a coat of the black varnish, to be afterwards mentioned, must be laid on the articles to be varnished. They must be allowed to dry well upon their moulds, that they may not assume any wrinkles, which prevent the proper distribution of the varnish.

Fourth Operation.—This first coat of varnish being perfectly dry, the pumice stone must be again resorted to, in order to remove any small inequalities which may remain.

Fifth Operation.—When the air is dry and warm, a second coat of the black varnish must be applied, and also polished with the pumice stone.

Sixth Operation.—The finishing hand must now be put to the article by laying on the varnish to be afterwards described, taking care to employ for this purpose a small and compact pencil, in order to spread the varnish uniformly and equally.

When the first coat of varnish is well dried, it must be sprinkled with pumice stone reduced to fine powder, and then rubbed all over with a wet sponge, or a piece of fine linen rag also wetted, in order to render the varnish perfectly smooth; or in place of pumice stone, with tripoli, soaked in oil and rubbed with the palm of the hand. As to the second and last coat of varnish, it must be polished when well dried, by sprinkling it with starch and rubbing it with a piece of old linen rag, which will give it a very fine lustre.

In the event of the varnish being tarnished, or losing its lustre by long usage, in order to restore it, place the articles of felt or leather in boiling water for a minute, then let them dry thoroughly, sprinkle them with starch, and rub them with a piece of dry linen, and they will resume their former lustre.

Preparation of Linseed Oil, under the denomination of Oil of Marmite.

Take Linseed oil	15	pounds
Umber	4	ounces
Red Lead	1	pound 8 ounces
White Lead	2	pounds 4 ounces

Put the whole into a pot placed upon a coal fire; boil it for thirty-six or forty minutes; stir it from time to time with a wooden spatula; and care must be taken that it is neither too little boiled, nor viscous, from being too much so.

Upon taking the pot off the fire, throw in a piece of bread, both crust and crumb, of the size of a small loaf. Cover it, and let it cool for twenty-four hours. The oil thus prepared is made use of for various purposes.

Composition of the Black Varnish.

1. Take of black umber two pounds thirteen ounces; cut it into small pieces, and place them in a frying pan upon a very brisk fire, and roast it like coffee for about three quarters of an hour; bruise it afterwards upon a marble-slab, by mixing it in the manner of painters, with a little boiled linseed oil, and keep it in a stone pot.

2. Take three pounds of verdigrise; reduce it to an impalpable powder; mix it with the boiled linseed oil; then put it into the stone pot which contains the umber.

3. Take of lamp-black one pound, mix it also with boiled linseed oil, and after putting it also, into the stone pot, blend the whole well together.

This is the mixture made use of to varnish articles of felt, cloth, or leather, observing that when leather is to be varnished, it is essential to give it previously two or three, and sometimes even six, coats of linseed oil; it must be well dried each time, in order to extract the grease from the leather, wax, or fish oil, in order that the varnish may incorporate with the leather more easily. This precaution must be made use of with soft boots, when placed upon moulds or boot-trees; and, without even taking them off, as many coats of varnish may be laid on as necessary.

Method of preparing the Varnish.

Take of Prussian blue	12	ounces
Indigo	12	

Bruise these two separately upon a marble slab; mix them up with a little oil, and put them in a pot by themselves.

Afterwards take of gum copal	8	ounces
Prepared nut oil	5	
Spirit of turpentine	14	

Put the gum-copal, bruised in a matrass with a large neck, upon a strong fire, but not flaming, taking care to stir it often, and to keep it uncovered. We know that the gum is totally dissolved when the smoke has entirely abated in the matrass; pour into it, by little and little, prepared nut oil, stirring it in order to incorporate the whole completely. Afterwards, and in the same manner, the spirit of turpentine is poured in, and the mixture is then taken from the fire, filtered, and cooled; it is then made use of to grind with the Prussian blue and indigo in small quantities at a time, and the whole is well mixed together.

This mixture forms the fine varnish for the purposes indicated.

14. Take of the best oil of turpentine 3 ounces, and of Indian rubber in slips a third of an ounce; put the whole in a close corked bottle, and keep it at the usual temperature for three or four days, in which time the Indian rubber will for the most part be dissolved, forming a tenacious thick fluid; pour this into a pint of drying linseed oil, and heat the mixture for a few minutes nearly to boiling, then take it from the fire and strain it while warm through a piece of linen. This is a very effectual varnish, but it is long in drying. The following therefore is to be preferred.

15 Take of very drying linseed oil, half a pint, and of birdlime 1 pound, put the mixture in an iron pot, and heat it nearly to boiling, till the birdlime ceases to crackle, then pour in 2½ pints more of drying oil, and boil it for about an hour with constant stirring, taking care that it does not boil over. When it has acquired so much tenacity that a little, rubbed between two knife blades, will draw out into threads on the separation of the blades from each other, it may be removed from the fire, and well mixed with a quart of oil of turpentine, and then strained and bottled. In order to apply it, the silk or linen must be quite dry and the varnish lukewarm; a thin coat is to be first laid on one side, and about twelve hours after, two other coats should be laid on, one on each side, and in twenty-four hours after, the stuff will be dry enough to be used.

The following varnishes may be also noticed.

Black Varnish for Coaches and Iron-Work.

This varnish is composed of asphaltum, resin, and amber, melted separately, and afterwards mixed; the oil is then added, and afterwards the turpentine, as directed above. The usual proportions are, twelve ounces of amber, two of resin, two of asphaltum, six of oil, and twelve of turpentine.

A Varnish for rendering Silk water and air tight.

To render the linseed-oil drying, boil it with two ounces of sugar of lead, and three ounces of litharge, for every pint of oil, till the oil has dissolved them; then put a pound of bird-lime, and half a pint of the drying-oil, into a pot of iron or copper, holding about a gallon; and let it boil gently over a slow charcoal fire, till the bird-lime ceases to crackle; then pour upon it two pints and a half of drying-oil, and boil it for an hour longer, stirring it often with an iron or wooden spatula. As the varnish, in boiling, swells much, the pot should be removed from the fire, and replaced when the varnish subsides. While it is boiling, it should be occasionally examined, in order to determine whether it has boiled enough. For this purpose, take some of it upon the blade of a large knife, and after rubbing the blade of another knife upon it, separate the knives; and when, on their separation, the varnish begins to form threads between the two knives, it has boiled enough, and should be removed from the fire. When it is almost cold, add about an equal quantity of spirits of turpentine; mix both well together, and let the mass rest till the next day; then, having warmed it a little, strain and bottle it. If it is too thick, add spirits of turpentine. This varnish should be laid upon the stuff when perfectly dry, in a lukewarm state; a thin coat of it upon one side, and, about 12 hours after, two other coats should be laid on, one on each side; and in 24 hours the silk may be used.

Mr. Blanchard's Varnish for Air-balloons.

Dissolve elastic gum (Indian-rubber) cut small, in five times its weight of spirits of turpentine, by keeping them some days together; then boil one ounce of this solution in eight ounces of drying linseed-oil for a few minutes, and strain it. Use it warm.

A Varnish for Wainscot, Cane Chairs, &c.

Dissolve in a quart of spirits of wine, eight ounces of gum-sandarach, two ounces of seed-lac, and four ounces of resin; then add six ounces of Venice-turpentine. If the varnish is to produce a red colour, more of the lac and less of sandarach should be used, and a little dragon's-blood should be added. This varnish is very strong.

A Varnish for Toilet-Boxes, Cases, Fans, &c.

Dissolve two ounces of gum-mastich, and eight ounces of gum-sandarach, in a quart of alcohol; then add four ounces of Venice turpentine.

A Varnish for Violins, and other Musical Instruments.

Put four ounces of gum-sandarach, two ounces of lac, two ounces of gum-mastich, an ounce of gum-elemi, into a quart of alcohol, and hang them over a slow fire till they are dissolved, then add two ounces of turpentine.

Varnish for employing Vermilion for painting Equipages.

Dissolve in a quart of alcohol six ounces of sandarach, three ounce of gum-lac, and four ounces of resin; afterwards add six ounces of the cheapest kind of turpentine; mix it with a proper quantity of vermilion when it is to be used.

White Varnish for Clock Faces, &c.

Take of spirits of wine (highly rectified) one pint, which divide into four parts; then mix one part with half an ounce of gum-mastich, in a phial by itself; one part of spirits, and half an ounce of gum-sandarach in another phial; one part of spirits, and half an ounce of the whitest parts of gum-benjamin. Then mix and temper them to your mind. It would not be amiss to add a little bit of white resin, or clear Venice-turpentine, in the mastich bottle; it will assist in giving a gloss. If your varnish prove too strong and thick, add spirits of wine only; if too hard, some dissolved mastich; if too soft, some sandarach or benjamin.

Varnishes should be carefully kept from dust, and in very clean vessels: they should be laid as thin and even as possible with a large flat brush, taking care to lay the strokes all one way. A warm room is best for varnishing in, as cold chills the varnish, and prevents it from laying even.

Varnishes are *polished* with pumice-stone and tripoli. The pumice-stone must be reduced to a very fine powder, and put upon a piece of serge moistened with water; with this the varnished substance is to be rubbed equally and lightly. The tripoli must also be reduced to a fine powder, and put upon a clean woollen cloth moistened with olive-oil, with which the polishing is to be performed. The varnish is then to be wiped with soft linen, and, when quite dry, cleaned with starch, or Spanish-white, and rubbed with the palm of the hand, or with a linen cloth.

Of Lacquers.

A lacquer is a transparent varnish applied to the surface of metals, both for the purpose of protecting them from the action of air and moisture, and for heightening their colour, and bringing it nearer to that of gold. The metals that are commonly lacquered are brass and tin. The following are some of the best varnishes for the purpose.

17. Take of turmeric pulverized, one ounce, and of saffron and annotto each 2 drachms; infuse them at a moderate temperature for a week or more in a pint of rectified alcohol: separate the yellow tincture thus obtained, by straining through a piece of clean linen, and add to the clear liquor three ounces of good seed lac: let the materials digest together for some days in a bottle, with frequent shaking, and then strain off the clear part, which is the lacquer. If the piece of brass to which it is to be applied is large, as a lock for example, it is to be warmed, and the lacquer also warm is to be spread on with a brush; if the articles are small they are to be made up into packets, then warmed, and afterwards dipped into the varnish.

Another lacquer for brass still cheaper than the foregoing, and nearly as good, is made by substituting half a drachm of the best dragon's blood instead of the saffron and annotto.

The following varnish may be applied to lamps, and other articles of tinned ware, in order to make them resemble brass.

18. Take of turmeric one ounce, and of dragon's blood two drachms; infuse the ingredients in a pint of alcohol, and when the tincture is completed, strain it through a piece of clean linen, and add to the clear liquor three ounces of seed lac; in a few days the solution will be completed, after which the varnish is to be strained, and is then fit for use.

One more lacquer remains to be mentioned, namely, that which is employed in the preparation of gilt leather as it is called. The appearance of gilding is produced on leather by fixing upon it, by means of strong size, very highly burnished tinfoil or silver leaf, and then coating the polished surface over with the following varnish.

19. Take of fine white resin $4\frac{1}{2}$ pounds, of common resin the same quantity, of gum sandarach $2\frac{1}{2}$ pounds, and of common aloes 2 pounds: melt the whole over a gentle fire, stirring them well at the same time with an iron spatula: when the fusion is complete add by degrees 7 pints of linseed oil, and make the whole

boil for six or seven hours, stirring it carefully all the time. When the varnish begins to get ropy, stir in half an ounce of red lead finely pulverized: as soon as this latter is completely dissolved, remove the varnish from the fire and strain it while warm through a linen or flannel bag.

VEG-ALKALI. The name given by Dr. Pearson, to Potash.

VEGETABLE ALKALI, in contradistinction of mineral alkali, a name given to potash. See Potash.

VEGETABLE KINGDOM. In the mineral kingdom little of chemical operation takes place, wherein the peculiar locality or disposition of the principles, which act upon each other, appears to have any considerable effect. The principles, for the most part simple, act upon each other by virtue of their respective attractions; if heat be developed, it is for the most part speedily conducted away; if elastic products be extricated, they in general make their escape; in a word, we seldom perceive in the operations in the mineral kingdom any arrangement, which at all resembles the artificial dispositions of the chemist.

But in the animal and vegetable kingdoms it is far otherwise. In the former of these, bodies are regularly changed by mechanical division, by digestion, and the application of peculiar solvents, in a temperature exceeding that of the atmosphere, and the whole of the effects are assisted, modified and kept up by an apparatus for admitting the air of the atmosphere. The subjects of the vegetable kingdom possess, undoubtedly a structure less elaborate. They exhibit much less of those energies, which are said to be spontaneous. The form of their vessels is much simpler, and, as far as we can perceive, their action is obedient to the changes of the atmosphere in quality and moisture, the mechanical action of winds, the temperature of the weather, and the influence of light. In these organized beings, the chemist discovers principles of a more compounded nature than any which can be obtained from the mineral kingdom. These do not previously exist in the earth, and must therefore be results of vegetable life.

The most obvious difference between vegetables and animals, is, that the latter are in general, capable of conveying themselves from place to place; whereas vegetables, being fixed in the same place, absorb by means of their roots and leaves, such support as is within their reach.—This appears on the whole, to consist of air and water. The greatest part of the support of animals, are the products already elaborated in the vegetable kingdom. The products of these two kingdoms in the hands of the chemist are remarkably different, though perhaps not exclusively so. One of the most distinctive characters, seems to be the presence of nitrogen or azotic gas, which may be extricated from animal substances, by the application of nitric acid, and enters into the composition of the ammonia, afforded by destructive distillation. It was long supposed, that ammonia was exclusively the product of the animal kingdom, but it is now well known, that certain plants likewise afford it.

When it is considered, that by far the greater part of every organized substance, is capable of assuming the elastic form, and being volatilized by heat; that the products during life, are brought into combination by slow and long-continued processes, and are kept separate from each other, in the vessels of the plant or animal; that these combinations are liable to be altered by the destruction of those vessels, as well as by every notable change of temperature, it will not appear surprising, that the chemical analysis of plants, should be in a very imperfect state.

The ancient chemists had no other methods of examining plants, than by destructive distillation, and the successive application of water and alcohol. They had no method of examining, the elastic products of their distillations. This method is on every account of little value. For the new combinations produced by the heat, exhibit products nearly similar from substances, originally very different. The other method by the application of solvents, is somewhat more accurate, and has besides afforded products of considerable utility in the arts, and for the ordinary purposes of life.

In the structure of vegetables, we observe the external covering or bark, the ligneous or woody matter, the vessels or tubes, and certain glandular or knotty parts. The comparative anatomy, and immediate uses of these parts, form an object of interesting research, but less immediately within the province of a chemical work.

The nutrition or support of plants appears to require water, earth, light, and air. There are various experiments, which have been instituted to show, that water is the only aliment, which the root draws from the earth. Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with sheet lead: he watered it for five years with

distilled water; and at the end of that time, the tree weighed 169 pounds three ounces, and the earth in which it had vegetated, was found to have suffered a loss of no more than three ounces. Boyle repeated the same experiment upon a plant, which at the end of two years, weighing 14 pounds more, without the earth in which it had vegetated, having lost any perceptible portion of its weight.

Messrs. Duhamel and Bonnet supported plants with moss, and fed them with mere water: they observed, that the vegetation was of the most vigorous kind; and the naturalist of Geneva, observes, that the flowers were more odoriferous, and the fruit of a higher flavour. Care was taken to change the supports, before they could suffer any alteration. Mr. Tillet has likewise raised plants, more especially of the gràmineous kind, in a similar manner; with this difference only, that his supports were pounded glass, or quartz in powder. Hales has observed, that a plant, which weighed three pounds, gained three ounces after a heavy dew. Do we not every day observe, hyacinths and other bulbous plants, as well as gramineous plants, raised in saucers or bottles containing mere water? And Bracannot has lately found mustard seed to germinate, grow, and produce plants, that came to maturity, flowered, and ripened their seed, in litharge, flowers of sulphur, and very small unglazed shot. The last appeared least favourable to the growth of the plants, apparently because their roots could not penetrate between it so easily.

All plants do not demand the same quantity of water; and nature has varied the organs of the several individuals, conformable to the necessity of their being supplied with this food. Plants which transpire litttle, such as the mosses and the lichens, have no need of a considerable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have scarcely any roots; but plants which require a larger quantity, have roots which extend to a great distance, and absorb humidity throughout their whole surface.

The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the same principle, which the root draws from the earth. But plants which live in the water, and as it were swim in the element, which serves them for food, have no need of roots; they receive the fluid at all their pores: and we accordingly find that the fucus, and the ulva, &c., have no roots whatever.

The purer the water, the more salutary it is to plants. Mr Duhamel has drawn this consequence from a series of well-made experiments, by which he has proved, that water impregnated with salts is fatal to vegetation Hales caused them to absorb various fluids by making incisions in their roots, and plunging them into alcohol, mercury, and various saline solutions; but he was convinced, that all these were poisons to the vegetables. Besides, if these salts were favourable to the plants, they would be again found in the individual, which had been watered with a solution of them; whereas Messrs. Thouvenel and Cornette have proved, that these salts do not pass into the vegetable. We must nevertheless except the marine plants, because the sea-salt of which they have need, is decomposed in them; and produces a principle, which appears necessary to their existence, since they languish without it.

Though it is proved, that pure water is more proper for vegetation than water charged with salts, it must not on this account be concluded, that water cannot be disposed in a more favourable manner to the developement of vegetables, by charging with the remains of vegetable and animal decomposition. If, for example, the water be loaded with principles disengaged by fermentation or putrefaction, the plant then receives juices already assimilated to its nature, and these prepared aliments must hasten its growth. Independent of those juices already formed, the nitrogen gas, which constitutes one of the nutritive principles of plants, and is abundantly afforded by the alteration of vegetables and animals, must facilitate their developement. A plant supported by the remains of vegetables and animals, is in the same situation as an animal fed on milk only; its organs have less difficulty in elaborating this drink, than that which has not yet been animalized.

From the preceding circumstances it appears that the influence of the earth in vegetation, is almost totally confined to the conveyance of water, and probably the elastic products from putrefying substances to the plant.

Vegetables cannot live without air.— From the experiments of Priestley, Ingenhoutz and Sennebier, it is ascertained, that plants absorb the azotic part of the atmosphere; and this principle appears to be the cause of the fertility, which arises from the use of putrefying matters in the form of manure. The carbonic acid is likewise absorbed by vegetables, when its quantity is small. If in large quantity, it is fatal to them.

Chaptal has observed, that carbonic acid predominates in the fungus, and other subterraneous plants. But by causing these vegetables, together with the body upon which they were fixed, to pass, by imperceptible gradations, from an absolute darkness into the light, the acid very nearly disappeared; the vegetable fibres being proportionally increased, at the same time that the resin and colouring principles were developed, which he ascribes to the oxygen of the same acid.—Sennebier has observed, that the plants which he was watered with water, impregnated with carbonic acid, transpired an extraordinary quantity of oxygen, which likewise indicates a decomposition of the acid.

Light is almost absolutely necessary to plants. In the dark they grow pale, languish and die. The tendency of plants toward the light, is remarkably seen in such vegetation, if it is effected in a chamber or place where the light is admitted on one side; for the plant never fails to grow in that direction. Whether the matter of light be condensed into the substance of plants, or whether it acts merely as a stimulous or agent, without which the other requisite chemical processes cannot be effected, is uncertain.

It is ascertained, that the processes in plants serve, like those in animals, to produce a more equable temperature, which is for the most part above that of the atmosphere. Dr. Hunter, quoted by Chaptal, observed by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere, when it was below the fifty-sixth division of Fahrenheit; whereas the vegetable heat, in hotter weather, was always several degrees below that of the atmosphere. The same philosopher has likewise observed, that the sap, which out of the tree, would freeze at 32° Fah. did not freeze in the tree unless the cold were augmented 15° more.

The vegetable heat may increase or diminish by several causes, of the nature of disease; and it may even become perceptible to the touch in very cold weather, according to Buffon.

The principles of which vegetables are composed, if we pursue their analysis as far as our means have hitherto allowed, are chiefly carbon, hydrogen, and oxygen.

The number of principles, both simple and compound [possessed of distinct characters] which have been extracted from vegetables, has been much increased by the investigation of modern chemists. Of these principles we shall here give an enumeration from the works of Dr. Thompson, a late celebrated writer on the subject, of their chemical characters; referring the reader for a further account of such of them as come within the nature of our work, to their place in alphabetical order.

1. *Sugar.* Crystallizes. Soluble in water and alcohol. Taste sweet. Soluble in nitric acid, and yields oxalic acid.

2. *Sarcocol.* Does not crystallize. Soluble in water and alcohol. Taste bitter sweet. Soluble in nitric acid, and yields oxalic acid.

3. *Asparagin.* Crystallizes. Taste cooling and nauseous. Soluble in hot water. Insoluble in alcohol. Soluble in nitric acid, and converted into bitter principle and artificial tannin.

4. *Gum.* Does not crystallize. Taste insipid. Soluble in water, and forms mucilage. Insoluble in alcohol. Precipitated by silicated potash. Soluble in nitric acid, and forms mucous and oxalic acids.

5. *Ulmin.* Does not crystallize. Taste insipid. Soluble in water, and does not form mucilage. Precipitated by nitric and oxymuriatic acids, in the state of resin. Insoluble in alcohol.

6. *Inulin.* A white powder. Insoluble in cold water. Soluble in boiling water; but precipitates unaltered after the solution cools. Insoluble in alcohol. Soluble in nitric acid, and yields oxalic acid.

7. *Starch.* A white powder. Taste insipid. Insoluble in cold water. Soluble in hot water; opake and glutinous. Precipitated by an infusion of nutgalls; precipitate redissolved by a heat of 120° Fah. Insoluble in alcohol. Soluble in dilute nitric acid, and precipitated by alcohol. With nitric acid yields oxalic acid and a waxy matter.

8. *Indigo.* A blue powder. Taste insipid. Insoluble in water, alcohol, ether. Soluble in sulphuric acid. Soluble in nitric acid, and converted into bitter principle, and artificial tannin.

9. *Gluten.* Forms a ductile elastic mass with water. Partially soluble in water; precipitated by infusion of nutgalls, and oxigenized muriatic acid. Soluble in acetic and muriatic acid. Insoluble in alcohol. By fermentation becomes viscid and adhesive, and then assumes the properties of cheese. Soluble in nitric acid, and yields oxalic acid.

10. *Albumen* Soluble in cold water. Coagulated by heat, and becomes insoluble. Insoluble in alcohol. Precipitated by infusion of nutgalls. Soluble in nitric acid. Soon putrefies.

11. *Fibrin.* Tasteless. Insoluble in wa-

ter and alcohol. Soluble in diluted alkalies, and in nitric acid. Soon putrefies.

12. *Gelatin.* Insipid. Soluble in water. Does not coagulate when heated. Precipitated bs infusion of galls.

13. *Bitter principle.* Colour yellow or brown. Taste bitter. Equally soluble in water and alcohol. Soluble in nitric acid. Precipitated by nitrate of silver.

14. *Extractive.* Soluble in water and alcohol. Insoluble in ether. Precipitated by oxigenixed muriatic acid, muriate of tin, and muriate of alumine; but not by gelatine. Dyes fawn colour.

15. *Tannin.* Taste astringent. Soluble in water and in alcohol of 0.810. Precipitated by gelatine, muriat of alumine, and muriat of tin.

16. *Narcotic principle.* Crystallizes. Sparingly soluble in hot water and alcohol.

17. *Fixed oils.* No smell. Insoluble in water and alcohol. Forms soaps with alkalis. Coagulated by earthy and metallic salts.

18. *Wax.* Insoluble in water. Soluble in alcohol, ether, and oils. Forms soap with alkalis. Fusible.

19. *Volatile oil.* Strong smell. Insoluble in water. Soluble in alcohol. Liquid. Volatile. Oily. By nitric acid inflamed, and converted into resinous substances.

20. *Camphor.* Strong odour. Crystallizes. Very little soluble in water. Soluble in alcohol, oils, acids. Insoluble in alkalis. Burns with a clear flame, and volatilizes before melting.

21. *Birdlime.* Viscid. Taste insipid. Insoluble in water. Partially soluble in alcohol. Very soluble in ether. Solution green.

22. *Resins.* Solid. Melt when heated. Insoluble in water. Soluble in alcohol, ether, and alkalies. Soluble in acetic acid. By nitric acid converted into artificial tannin.

23. *Guaiacum.* Possesses the characters of resins, but dissolves in nitric acid, and yields oxalic acid and no tannin.

24. *Balsams.* Possess the characters of the resins, but have a strong smell; when heated, benzoic acid sublimes. It sublimes also when they are dissolved in sulphuric acid. By nitric acid converted into artificial tannin.

25. *Caoutchouc.* Very elastic. Insoluble in water and alcohol. When steeped in ether reduced to a pulp, which adheres to every thing. Fusible, and remains liquid. Very combustible.

26. *Gum resins.* Form milky solutions with water, transparent with alcohol. Soluble in alkalies. With nitric acid converted into tannin. Strong smell. Brittle, opake, infusible.

27. *Cotton.* Composed of fibres. Tasteless. Very combustible. Insoluble in water, alcohol, and ether. Soluble in alkalis. Yields oxalic acid to nitric acid.

28. *Suber.* Burns bright and swells. Converted by nitric acid into suberic acid and wax. Partially soluble in water and alcohol.

29. *Wood.* Composed of fibres. Tasteless. Insoluble in water and alcohol. Soluble in weak alkaline lixivium. Precipitated by acids. Leaves much charcoal when distilled in a red heat. Soluble in nitric acid, and yields oxalic acid.

VEINS. See METALS, METALLURGY, and ORES.

VENETIAN RED. See COLOUR-MAKING.

VENEERING.—Veneering is a species of inlaying or marquetry, in which several thin leaves, or slips of fine wood, are applied to a ground-work of common wood. It is performed in the following manner.

The wood intended for veneering, is first fixed in a vice, or sawing press, where it is divided into leaves, not exceeding one line in thickness. Such leaves are then cut into small slips of various forms, according to the design proposed: and, when the ground-work is duly prepared, they are cemented by means of glue, and submitted to the action of a press, till the whole becomes perfectly dry; after which the articles are scraped and polished.

The veneering with mahogany, in consequence of the high price of that wood, is now generally adopted by the cabinet-makers.

VENUS, *Crystals of.* See COPPER.

VENTILATION. Various contrivances have been made for ventilating with fresh air the holds of ships, hospitals, granaries, &c.

For warming and ventilating ships Mr. Pettibone has given the following observations.

The application of the following plan is manifestly advantageous in warming and ventilating merchant ships and vessels of war, viz.—A boiler, or air-vessel, may be fixed in furnace, fire-place or camboose; and to the bottom of the boiler a tube is introduced, which passes from it down the inside of the ship or vessel, nearly to the keel, where it forms a curve and returns again above the deck. At this place it admits the external air, which passes through the tube into the boiler or air-vessel; and, after it is heated, it passes out of another tube inserted into the upper part of the air-vessel; and the heated air may then be conducted into any part of the ship or vessel. These tubes must be made double, and the intermediate space between the tubes should be filled

with powdered charcoal, so as to prevent the escape of heat. Also, if the receiving tube penetrates into the hold of the ship, and conducts the foul air within the ship, into the boiler or air-vessel, and, after being heated there, into another tube fixed into the superior part of the boiler or air-vessel, which conveys it into the atmosphere above the deck, where it mixes with the general mass. This improvement can be very beneficially applied to ventilate mines, wells, school rooms, assembly rooms, and any apartments or places, impregnated with foul air.

To effect this without warming the room, the boiler or air-vessel and stove should be placed above it. However, the room can be warmed with the stove above (if rightly fitted) nearly as well as if the stove was below.

When it is found, (says Mr. Pettibone,) that the external air is warm, and the apartment is crowded with people, it is proper that ventilation should take place at the top, at or near the ceiling.—Whenever an apartment is filled with contaminated air, particularly in the summer, by the perspiration or breath of a crowded assembly, or from burning of candles or lamps, or from any other cause, it is of much consequence, that tin, pasteboard, or other tubes (filled between with charcoal,) should be placed just above the lights, and carried into the external atmosphere, by placing one or more of Argand's patent lamps in or near the end of the tubes.—The air in the tube becomes rarefied; and by the current of air up the tubes, the ventilation is made to be more complete.

An account of Hale's ventilators may be seen in the Philosophical Transactions, and that of Abernethy in a late volume of Phillips's Monthly Magazine, and in Dr. Gleig's supplement to the Encyclopedia Britannica of Edinburgh.

Mr. Benjamin Wynkoop's contrivance for ventilation consists of four bellows connected in a frame, and having their nozzles opening into one tube which descends from the deck to any distance in the hold of the vessel; and as the frame of the upper part of the bellows, or moving frame, is furnished at bottom with a heavy pendulum or weight, and the other or standing part of the frame, is attached either to the side of the ship, and parallel therewith, or to some partition at right angles with the keel, or which is preferable, to both, the motion of the ship keeps one or other of them in constant operation, and precludes the necessity of manual labour.

Air-pump ventilator, for the ventilating of ships, mines, prisons, hospitals, &c. invented by Richard Robotham, *of the city of Hudson* (N. Y.).

"It is a single bellows, fitted upon the top of a tube of wood, or a trunk made of plank, which, in a ship, stands in the lowest part of the hold, by the kelson, and runs up through the lower deck. The bellows is fixed on the top of this trunk, with a valve at the usual place, at the inlet. The outlet of the bellows is made of wood, with a square angle, which turns upwards, and a valve in the upright part, that shuts down, in such manner that the bellows fills from the bottom, and discharges at the top. If the bellows discharges one barrel at a time, the insides of the trunks must be six inches square; it will be then sufficient for a vessel of three hundred tons; but if they are four or five times this size, the machine may be worked by the labour of one man; or, about one square inch of enlargement may be made in the trunks to each gallon in the bellows: then it will fill and discharge about twenty times in a minute. The bellows may be made in various shapes and sizes at pleasure. This improvement consists altogether in filling the bellows at, or from the bottom, and discharging the contents at the top, above the upper deck, or out of a port-hole."

Ventilation of Ovens.

Ventilation in the oven (says Mr. Pettibone) is of importance. It not only adds to the flavour of the articles baked or cooked, but tends to expedite the process. In order to perform this operation, a cast or wrought iron pipe or tube, of the size of a gun-barrel, should be placed in the hottest part of the stove under the oven plate, and one end connected with the air of the room, or the external air which is preferable.—The other end is to enter the oven through the oven plate, at the back end of the plate or oven; then it is to rise nearly to the top. I have then another pipe leading downward from the under side of the smoke tube or flue, within the oven, near the oven plate. In this oven, as the hot air from without enters the top of the oven, it forces the fumes downwards to enter the pipe that leads into the smoke flue.—Dampers or registers are fitted in the pipes, to regulate the current of air going in or out of the oven, to ventilate it more or less. Ventilators were invented by Dr. Hales in 1740.

VERDIGRISE is copper corroded, and reduced to a very beautiful green rust, by a vinous acid. This matter, which is useful to painters, is conveniently manufactured at Montpellier; the vines of Languedoc, of which that city is the capital, being very proper for this preparation.

The following process for making ver-

digrise is described by Mr. Monnet of the Royal Society of Montpellier, and is published among the Memoirs of the Academy for the years 1750 and 1753.

Vine-stalks, well dried in the sun, are steeped during eight days in strong wine, and afterwards drained. They are then put into earthen pots, and upon them wine is poured. The pots are carefully covered. The wine undergoes the acetous fermentation, which in summer is finished in seven or eight days, but requires a longer time in winter, although this operation is always performed in cellars. When the fermentation is sufficiently advanced, which may be known by observing the inner surface of the lids of the pots, which during the progress of the fermentation is continually wetted by the moisture of the rising vapours, the stalks are then to be taken out of the pots. These stalks are by this method impregnated with the acid of the wine, and the remaining liquor is but a very weak vinegar. The stalks are to be drained during some time in baskets, and layers of them are to be put into earthen pots, with plates of Swedish copper, so disposed that each plate shall rest upon, and be covered with layers of stalks. The pots are to be covered with lids, and the copper is thus exposed to the action of the vinegar, during three or four days, or more, in which time the plates become covered with verdigrise. The plates are then to be taken out of the pots, and left in the cellar three or four days; at the end of which time they are to be moistened with water, or with the weak vinegar above mentioned, and left to dry. When this moistening and drying of the plates has been thrice repeated, the verdigrise will be found to have considerably increased in quantity, and it may then be scraped off for sale.

A solution or corrosion of copper, and consequently a verdigrise, may be prepared by employing ordinary vinegar instead of wine, as is directed in the above process. But it would not have the unctuosity of ordinary verdigrise, which quality is necessary in painting. Good verdigrise, according to Macquer, must be prepared by means of a vinous acid, half acid and half spirit. Accordingly the success of the operation depends chiefly on the degree of fermentation, to which the wine employed has been carried: for this fermentation must not have been so far advanced, that no sensibly vinous or spirituous part remains in the liquor.

Verdigrise is used for painting, as it furnishes a fine green colour, when mixed with oil. It enters also as an ingredient into several plasters and ointments. In chemistry, verdigrise is used for the extraction of acetic acid, and for the preparation of crystals of verdigrise, or of Venus.

Chaptal informs us, that the fabrication of this article was till lately confined to Montpellier, from a prejudice, that the cellars of that city alone were proper for the operation. His account of the manufacture is less ample than the foregoing, but in effect the same. This article is also made at Grenoble, where ready made vinegar is used, and sprinkled on plates of copper. This verdigrise contains one-sixth part less of copper than that of Montpellier, and has not the empyreumatic smell of the latter. The vinegar it affords by distillation is likewise stronger and in greater plenty. Whence he concludes, that part of the oxide of copper in this compound is really dissolved, and brought into the saline state.

VERDITER is a blue pigment, obtained by adding chalk or whiting to the solution of copper in aquafortis. It is prepared by the refiners, who employ for this purpose the solution of copper, which they obtain in the process of parting, by precipitating silver from aquafortis with plates of copper. It is said, that a fine coloured verditer cannot be obtained from a solution of copper prepared by dissolving directly that metal in aquafortis; and that the silver is necessary. We know, that it is actually made of a good quality by the refiners only. Dr. Merret says that it is prepared in the following manner: A quantity of whiting is put into a tub, and upon this the solution of the copper is poured. The mixture is to be stirred every day for some hours together, till the liquor loses its colour. The liquor is then to be poured off, and more solution of copper is to be added. This is to be repeated till the whiting has acquired the proper colour. Then it is to be spread on large pieces of chalk and dried in the sun.

We have two kinds of verditer in the English market: the one, called refiners' verditer, has the form of a very soft impalpable powder, and possesses a stronger body of colour than the other. The other verditer has the form either of hard irregular lumps, or powder, in which last state it is much harsher to the feel, and is by no means so readily diffusible in water. The best verditer is, as we understand, made by the refiners, not because their solution of copper possesses any peculiar advantage over any other nitric solution, but because they obtain

it more cheaply, than if the acid had not been already paid for in their process of parting. The value of the article is not sufficient to pay for the expense of a direct solution in that country.

Common verditer is made from the sulphat of copper, which may be had at a reasonable rate from the manufacturers at Sheffield and Birmingham (England). We are not acquainted with that part of their manufactories which affords it, but understand, that it is not produced in a direct way, but from clipping of metal, or other savings. It is frequently contaminated with iron. The copper of a solution of this sulphat, is precipitated by an addition of lime in the making of common verditer. Whiting will not effect a separation. The precipitate afforded by the lime is blue, but requires some management as to the quantities of water as well as of the other principles, and the method of the drying, to produce the best effect.

The flintiness or harshness of the common verditer arises no doubt from an admixture of sulphat of lime; whereas in the refiners' verditer, little of lime is found; because the nitrate of lime is very soluble in the water. If the object should be found of sufficient commercial importance, it is probable that the blue oxide of copper in verditer might be obtained by an indirect process of transferring nitric acid to the metal. Thus, if the solutions of nitre, and of sulphat of copper, be mixed, the alkali unites with the sulphuric acid, and sulphat of potash falls down, if the quantity of water be not considerable; at the same time that the nitric acid transferred to the copper remains in solution.

Other methods of decomposition might be easily pointed out, but every thing of this nature must be referred to the test of experiment. For in some instances, triple compounds are formed where perfect decomposition was expected, and in most instances the complete edulcoration of the product is required, and many apparently minute circumstances must be investigated and attended to, where so delicate a thing as the colour of a metallic oxide is the object aimed at.

The refiners' verditer, is more than twice as dear as the common. Both, are used in water colours only, chiefly by the paper stainers. It is said, that the greater intensity of colour, added to the facility with which it may be uniformly spread over any surface, affords the advantage even of cheapness to the refiners' verditer; but the last mentioned quality is communicated to common verditer, by steeping it for several days in water before it is used.

VERJUICE.—A kind of harsh austere vinegar, made of the expressed juice of the wild apple or crab.

VERMILION. See Mercury.

VIBRATION OF THE PENDULUM. See Mechanics.

VIGOGNE DYE.—The milky juice of the white bell flowers is said to impart a beautiful green colour, by the addition of alum. The juice of the blue flowers alone has been used for painting and writing; and Dambourney asserts, that with these flowers he dyed wool and cloth of a fine *vigogne* colour, having previously immersed them in a properly diluted solution of bismuth.

Dambourney obtained from the stalks and leaves of the mezereon, a fine *vigogne* dye; and the stalks alone, imparted a beautiful gold-brown shade to wool, previously dipped in a diluted solution of bismuth. From the ripe berries of this plant, an excellent red lake is prepared by painters.

VINEGAR. *Essig*, Germ.—Vinegar is a liquor of an agreeable smell, a pleasant and strongly acid taste, and of a hue varying from light red to brown straw colour, and is prepared by fermenting any substance or compound which has already undergone the spirituous fermentation. Vinegar therefore may be made immediately from any wine, malt liquor, cyder, &c. or from the juice of the grape and other fruits, from infusion of malt, or any saccharine liquid, through the intermedium of vinous fermentation. Both these methods are actually practised with complete success.

The chemical properties of the pure acid of the different kinds of vinegar (which appears to be the same in all) have been already described under the article Acetous Acid, and we shall therefore only mention the usual processes of manufacture.

To make vinegar out of a liquor containing suitable materials, it is only necessary, 1st. to allow some access of air to the vessel in which it is kept, and, 2d. to keep it in a temperature rather higher than that of the atmosphere in this climate, that is to say, about 75° to 80°. It is also almost essential where a liquor already fermented is employed, to add a portion of yeast, or any other ferment, for though any fermented liquor, if kept in a moderate temperature in an open vessel, will spontaneously turn sour or become changed to vinegar, this change is too gradual to produce this acid in perfection, and the first acetified portion

turns mouldy before the last has become sour. But where the substance employed has not yet undergone fermentation, the whole process of the vinous and subsequent acetous fermentation will go on uninterruptedly with the same ferment which at first set it in action, which happens, for example, in the making vinegar from malt, or from sugar and water.

As even vinegar is not the ultimate change which a vinous liquor spontaneously assumes, there is a period in the process of the manufacture in which the acid is in its highest degree of strength and perfection, after which, if the process is not stopped, the liquor speedily deteriorates, the acetous acid gradually disappears, and only an offensive mouldy watery liquid remains, with scarcely any sourness. It belongs therefore to the skill and experience of the manufacturer to know when his vinegar is complete, and fit to be drawn off and closely barrelled.

Vinegar was doubtless (as its name imports) originally made from wine, and this is the material which furnishes it probably in the greatest perfection, and is employed solely in the wine countries. It is prepared by adding wine lees to wine, which excites a new fermentation that is kept up till the whole is changed to vinegar. Any wine will answer the purpose; the best and fullest-bodied wine gives the strongest vinegar, and that which is already soured and injured by keeping may be applied to this use. The actual method pursued in Paris is the following. A quantity of wine lees is put into a large tun, and worked up with wine sufficient to render it very fluid. This is then put into cloth sacks, which are arranged in a large iron-bound wooden vat, the heavy cover of which is laid over them, and serves as a press, that is gradually screwed down till all the liquor is pressed out. The wine, thus loaded with the extractive and tartareous matter of the lees, is distributed in large casks set upright, through the heading of which a hole is cut which is constantly left open. In summer these casks are simply set in the sun, but in winter they are arranged in a stoved room. The fermentation comes on in a day or two, and when it has got to its height, so much heat is excited, that sometimes the hand can hardly be borne in it. In this case, it must be checked by a cooler air, and by adding some fresh wine to the casks, and indeed it is in a due regulation of the heat that most of the practical skill of the maker consists. The process goes on in this way till the whole of the wine is thoroughly acidified, which requires about a fortnight in summer and a month in winter; after which the new vinegar is put into barrels, at the bottom of which are laid a good many chips of beech wood. Here it remains for about a fortnight, during which time it clarifies, and the clear part is then drawn off and kept in well closed casks. These beech chips may be used over and over again for several years.

The natural colour of good wine vinegar is a very pale red, but a higher colour is given, if desired, by the addition of elder-berries.

There are several slight variations in the mode of making wine vinegar, but which need not be detailed. They all consist in exciting a fresh fermentation in wine, and keeping it up in a moderate degree till acetification is complete. Many refuse parts of the vine are of use for this purpose, such as the husks, the sour succulent twigs, the marc or cake left in the wine press, and the like; and after they have once served, they are still more valuable, as the acid which they naturally contain, or which is evolved by them, is more readily produced.

Wine may also be converted to good vinegar without these additions, simply by adding wine, especially when on the fret, to vinegar already made, and exposing it to a proper heat. In this way many manufacturers proceed, keeping their casks always full by taking out of them at intervals about a third or fourth part, replenishing them with wine, and again bringing the contents to the state of vinegar.

In Europe vinegar is chiefly made from malt The following is the usual process in London. A mash of malt and hot water is made, which, after infusion for an hour and a half, is conveyed into a cooler a few inches deep, and thence, when sufficiently cooled, into large and deep fermenting tuns, where it is mixed with yeast, and kept in fermentation for four or five days. The liquor (which is now a strong ale without hops) is then distributed into smaller barrels set close together in a stoved chamber, and a moderate heat is kept up for about six weeks, during which the fermentation goes on equally and uniformly till the whole is soured. This is then emptied into common barrels, which are set in rows (often of many hundreds) in a field in the open air, the bung-hole being just covered with a tile to keep off the wet, but to allow a free admission of air. Here the liquor remains for four or five months, according to the heat of the weather, a gentle fermentation being kept up, till it becomes perfect vi-

negar. This is finished in the following way. Large tuns are employed, with a false bottom, on which is put a quantity of the refuse of raisins or other fruit left by the makers of raisin and other home-made wines, called technically *rape*. These rape tuns are worked by pairs; one of them is quite filled with the vinegar from the barrels, and the other only three-quarters full, so that the fermentation is excited more easily in the latter than the former, and every day a portion of the vinegar is laded from one to the other till the whole is completely finished and fit for sale.

Vinegar, as well as fruit-wines, is often made in small quantity for domestic uses, and the process is by no means difficult. The materials may be either brown sugar and water alone, or sugar with raisins, currants, and especially ripe gooseberries. These should be mixed in the proportions which would give a strong wine, put into a small barrel, which it should fill about three-fourths, and the bung-hole very loosely stopped. Some yeast, or, what is better, a toast sopped in yeast should be put in, and the barrel set in the sun in summer, or a little way from a fire in winter, and the fermentation will soon begin. This should be kept up constant but very moderate, till the taste and smell indicate that the vinegar is complete. It should be poured off clear and bottled carefully, and it will keep much better if it is boiled for a minute, cooled and strained before bottling.

Mr. Joseph Cooper, of New Jersey, says Dr. Mease, makes his vinegar of good bodied cyder, fills the barrel one-third full, and permits it to stand with the bung-holes slightly covered for at least nine months. If the fermentation does not proceed with sufficient rapidity, he draws off a few quarts of the liquor, and after boiling and skimming it, returns it again into the cask. Mr. Cooper confirms the utility of the practice of adding cyder or rye-spirit to weak vinegar to increase its strength.

Mr. William Sheaff, of Philadelphia, continues the Dr. adds one quart of bruised and ripe sumach-berries, after being boiled with half an ounce of cream of tartar, to every barrel of cyder destined for vinegar. He fines it, by pouring in one quart of fresh blood, beaten up with a handful of salt.

To prevent a mould forming on vinegar, several methods have been proposed. 1. To prepare vinegar very strong and sour. 2. To concentrate the vinegar by freezing, after which a hole is made in the crust of ice which covers it, through which the part not congealed is let out, and afterwards may be bottled. By this process, more than one half is lost. 3. To fill the bottles and keep them well corked. 4. To distil the vinegar in a *glass* retort. The following is the easiest method.

Boil vinegar in a *well tinned* kettle for a quarter of an hour, and bottle it, or fill the bottles with vinegar, and put them into a kettle full of water upon the fire. After the water has boiled for an hour, the bottles are taken out of the pot, and corked. Vinegar thus boiled will keep for several years without growing turbid or mouldy.

The following remarks are from the pen of Dr. Willich.

Wine-vinegar....Let any quantity of vinous liquor be mixed with its own lees or fæces, or with the acid and austere stalks of the vegetable from which wine was prepared. The whole must be frequently stirred, and either exposed to the sun, or deposited in a warm place: after standing a few days, it will ferment, become sour; and, in a fortnight, it will be converted into vinegar....Such is the usual manner of producing this acid; which is frequently rectified by distillation, when it is known under the name of distilled vinegar.

Cyder-vinegar, may be made by fermenting new cyder with the *must* of apples, in a warm room, or in the open air, where it should be exposed to the sun; and, in the course of a week or nine days, it will be fit for use.

Another method of preparing vinegar, is that published by M. Heber: it consists in exposing a mixture of 72 parts of water, and four of rectified malt-spirit, in a temperature of from 70 to 80° of Fahrenheit, for about two months; at the expiration of which the acetous process will be completed....A cheaper, though more tedious mode, is that of dissolving 2 lbs. of molasses in nine quarts of boiling water: this solution must be poured into a vessel containing a large quantity of cowslips; and, when the mixture becomes cool, a gill of yeast should be added. The whole is then to be exposed to the rays of the sun: at the end of three months, it may be bottled for use, and will be of peculiar service in pickling.

Tarragon-vinegar, is manufactured, by infusing one pound of the leaves of that vegetable (which have been gathered a short time before it flowers) in one gallon of the best vinegar, for the space of 14 days; when it should be strained through a flannel bag; and a drachm of isinglass, dissolved in cyder, must then be added;

the whole be carefully mixed, and decanted into bottles for a month. Thus, the liquor will acquire a most exquisite flavour; it will become remarkably fine, and almost colourless.

Vinegar contains a considerable quantity of colouring extractive matter, from which it can only be freed by distillation, the process of which, together with the chemical properties of this acid, have been mentioned under the article *Acetous Acid.*

When vinegar is long kept, especially exposed to the air, it becomes muddy, acquires a mouldy unpleasant smell, loses its clear red colour and all its properties, and finally is changed to a slimy mucilage and water.

VIOLET.—The *odorata*, or Sweet Violet, is perennial; grows in warm lanes, hedges, and ditch-banks, especially in clayey or marly soils: flowers in the months of April and May... Both the blossoms and seeds of this plant are mildly laxative; and, when taken in doses of from 40 to 80 grains, the powdered root operates as a purgative, and likewise as an emetic....Large quantities of violets are cultivated at Stratford-upon-Avon, for their petals, to impart their colour to *syrup of violets;* an officinal preparation of which is kept in the shops, and proves an agreeable and useful laxative for children. Such syrup may also be employed in many chemical inquiries, for discovering the presence of an *acid*, or an *alkali;* the former changing the blue colour to a red, and the latter to a green: though slips of white paper, stained with this juice, and preserved from the access of air and light, may serve as a substitute for that purpose.

VIOLET DYE. See Dyeing.

VITAL AIR. See Oxygen.

VITRIFICATION. See Glass.

VITRIOL, *native.*—It is more or less soluble in water, and is a mixture in various proportions of the sulphates of iron, copper, and zinc.

It not unfrequently occurs in caverns and shafts, in argillaceous schistus, and in old mines, especially such as abound in blende and pyrites.

VITRIOL, *blue.* See Copper.

VITRIOL, *green.* See Iron.

VITRIOL, *white.* See Zinc.

VITRIOLIC ACID. See Sulphuric Acid.

VOLATILITY. That property of bodies by which they are disposed to assume the vapourous or elastic state, and quit the vessels in which they are placed. In many instances of chemical operation, the most simple substances are found to be the most volatile, and many principles are rendered more fixed by combination. This is the most general observation; but there are a number of instances, in which volatility follows from combination, though for the most part less in degree than was possessed before by the more volatile of the matters so combined. Of all substances known the earths, are the less volatile, next to these are some of the metals, and these are followed by the fixed alkalies, and a few of the acids. All other bodies possess considerable volatility.—Very volatile bodies, are in many instances fixable in combination with others, by the sudden application of a fusing heat.

VOLCANOES. The combustion of those enormous masses of bitumen, which are deposited in the bowels of the earth, produces volcanoes. They owe their origin more especially to the strata of pyritous coal. The decomposition or action of water upon the pyrites, determines the heat, and the production of a great quantity of hydrogen, which exerts itself against the surrounding obstacles, and at length breaks them. This effect appears to be the chief cause of earthquakes; but when the concourse of air, facilitates the combustion of the bitumen, and the hydrogen, the flame is seen to issue out of the chimneys or vents, which are made: and this occasions the fire of volcanoes.

There are many volcanoes still in an active state on our globe, independent of those of Italy, which are the most known. The Abbe Chappe has described three burning in Siberia. Anderson and Von Troil has described those of Iceland.—Asia and Africa contain several: and we find the remains of these fires or volacnic products, in all parts of the globe.

Naturalists inform us, that all the southern islands have been volcanized; and they are seen daily to be formed by the action of these subterraneous fires. The black colour of the stones, their spongy texture, the other products of fire, and the identity of these substances, with those of the volcanoes at present burning, are all in favour of the opinion, that their origin was the same.

When the decomposition of the pyrites is advanced, and the vapours and elastic fluids can no longer be contained in the bowels of the earth, the ground is shaken, and exhibits the phænomena of earthquakes. Mephitic vapours are multiplied on the surface of the ground, and dreadful hollow noises are heard. In Iceland, the rivers and springs are swallowed up; a thick smoke mixed with sparks

and lightning, is then disengaged from the crater; and naturalists have observed, that, when the smoke of Vesuvius takes the form of a pine, the eruption is near at hand.

To these preludes, which show the internal agitation to be great, and that obstacles oppose the issue of the volcanic matters, succeeds an eruption of stones and other products, which the lava drives before it; and lastly appeais a river of lava, which flows out, and spreads itself down the side of the mountain. At this period the calm is restored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter, sometimes cause the sides of the mountain to open; and this is the cause which has successively formed the smaller mountains that surround volcanoes. Montenuevo, which is 180 feet high, and 300 in breadth, was formed in a night.

This crisis is sometimes succeeded by an eruption of ashes, which darken the air. These ashes are the last result of the alteration of the coals; and the matter which is first thrown out, is that which the heat has half vitrified. In the year 1767, the ashes of Vesuvius were carried 20 leagues out to sea, and the streets of Naples were covered with them. The report of Dion, concerning the eruption of Vesuvius in the reign of Titus, wherein the ashes were carried into Africa, Egypt and Syria, seems to be fabulous. Mr. de Saussure observes, that the soil of Rome is of this character, and that the famous catacombs, are all made in the volcanic ashes.

It must be admitted, however, that the force with which all the products are thrown is astonishing. In the year 1769, a stone 12 feet high and 4 in circumference, was thrown to the distance of a quarter of a mile from the crater: and in the year 1771, Sir William Hamilton observed stones of an enormous size, which employed eleven seconds in falling. This indicates an elevation of near 2000 feet.

The eruption of volcanoes is frequently aqueous: the water, which is confined, and favours the decomposition of the pyrites, is sometimes strongly thrown out. Sea salt is found among the ejected matter, and likewise sal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, destroyed Portici and Torre del Greco. Sir W. Hamilton saw boiling water ejected. The springs of boiling water in Iceland, and all the hot springs which abound at the surface of the globe, owe their heat only to the decomposition of pyrites.

Some eruptions are of a muddy substance; and these form the tufa, and the puzzolano. The eruption which buried Herculaneum is of this kind. Sir W. Hamilton found an antique head, the impression of which was well enough preserved to answer the purpose of a mould. Herculaneum at the least depth is 70 feet under the surface of the ground, and in many places 120.

The puzzolano is of various colours. It is usually reddish; sometimes gray, white, or green; it frequently consists of pumice stone in powder; but sometimes it is formed of oxided clay. One hundred parts of red puzzolano afforded Bergman, silex 55, alumine 20, lime 5, iron 20.

When the lava is once thrown out of the crater, it rolls in large rivers down the side of the mountain to a certain distance, which forms the currents of lava, the volcanic causeways, &c. The surface of the lava cools, and forms a solid crust, under which the liquid lava flows. After the eruption, this crust sometimes remains, and forms hollow galleries, which Messrs. Hamilton and Ferber have visited: it is in these hollow places that the sal ammoniac, the muriate of soda, and other substances, sublime. A lava may be turned out of its course, by opposing banks or dikes against it: this was done in 1669, to save Catania; and Sir W. Hamilton proposed it to the king of Naples, to preserve Portici.

The currents of lava sometimes remain several years in cooling. Sir W. Hamilton observed, in 1769, that the lava which flowed in 1766 was still smoking in some places.

W.

WADD, a name given to plumbago, or black lead.

WADD, BLACK, an ore of manganese, found in Derbyshire, England, remarkable for taking fire with linseed oil.

WAGGON, a species of wheel carriage, the form of which varies according to the purpose designed. We do not mean to treat very extensively on this subject, but to add a few remarks on carriages, wheels, the draught of horses, &c. and refer the reader for more particular information to Anderson's Dissertation, Recreations in Agriculture, and Walker's Lectures. For information on rail-roads, see RAILWAY.

The following observations are made principally from facts.

Dr. Willich observes, that few implements of husbandry are of greater importance, or admit, perhaps, of more essential improvements, than wheel-carriages. Hence we cannot but express our surprise at the infatuation of those farmers, who employ large waggons, on the erroneous principle, that a greater quantity may thus be carried at one time; while they overlook the injury which such unwieldy machines occasion, both in their fields, and particularly on roads, by making deep ruts, and otherwise tearing or breaking up the soil. The principal objection to the use of these heavy vehicles on farms, is their *weight;* which requires an increased number of horses or cattle, that might be more profitably employed in tillage. The same observation is applicable to the common *road* or *stage-waggons:* these usually weigh about 2½ tons, and are drawn by 8, 10, or more horses, according to the distance to which they travel. Now, a single horse, of a moderate size, will, in a well-constructed vehicle, and on tolerable roads, draw 30 cwt. with ease, independently of the weight occasioned by the cart: and it will perform this task for a series of days, months, and even years. But, if the common waggons were laden according to such draught, they ought to carry from 20 to 40 tons; a weight exceeding their strength, and incompatible with their mode of construction. The superiority of small carriages being too evident to require any farther demonstration, we shall subjoin a table, exhibiting the load which waggons and carts are permitted to draw on the turnpike-roads in England; and which includes both the whole incumbent load, and the vehicle itself.

	Summer Weight.			Winter Weight.		
	tons.	*cwt.*	*qrs.*	*tons.*	*cwt.*	*qrs.*
Waggons, with wheels not exceeding 9 inches, .	6	0	0	5	10	0
Ditto, with wheels not exceeding 6 inches, .	4	5	0	3	15	0
Ditto, with wheels not exceeding 3 inches, .	3	10	0	3	0	0
Carts, with wheels not exceeding 9 inches, .	3	0	0	2	15	0
Ditto, with wheels not exceeding 6 inches, .	2	12	0	2	7	0
Ditto, with wheels not exceeding 3 inches, .	1	10	0	1	7	0

We do not know, whether any regulation exists with respect to the turnpike roads of the United States, but this much is certain, that if an uniform custom was established, the teams would be restricted in their loads, and carriages generally be subject to better regulation. In a report made to the house of commons, it appears that this subject has been seriously considered, and several acts of parliament have been made to this end.

Mr. Walker made several experiments on the subject of draught horses, and in relation generally to wheel carriages. He observes, that single horse carts are preferable to teams; that four horses, with each a properly constructed cart, will draw much more, and with more ease to themselves, than when they are yoked in a team to one cart; because, in that case, three of the horses must draw horizontally, and consequently in a manner inconsistent with their mechanism, and the established laws of mechanics. The horse's collar is also drawn against his throat, by which his breathing is interrupted; and in cart teams, (where the horses are not marshalled, as in waggons,) one horse is standing still, perhaps, while another is wasting his strength in pulling him forward....One horse, to relieve himself, leans on one way out of the

line of draught, while another is leaning a contrary way; in short, their strength is seldom united.

From a number of experiments made by Mr Walker, for the purpose of determining the proper draught, there appeared to be an evident disadvantage in drawing from above the centre; and on the contrary, a considerable increase of power in drawing from the axles. Hence he concludes, as the splinter bar, or point of draught, in most carriages, is placed about one fourth the diameter of the fore wheel above its centre, it is evident, that a pressure equal to one fifth of whatever weight lies upon it, is actually added to the natural weight, by this situation of the point of draught. For 24 oz. surmounted the obstacle when the pull was from the centre, and 30 oz. were required to surmount it, at half the length of a spoke above the centre.

From Mr. Walker's experiments to ascertain the best proportions between the height of the fore and hind wheels, it appeared, that there was little superiority or inferiority in all the variety of combinations of heights between fore and hind wheels. Fore wheels, however, of four feet eight inches, and hind wheels of five feet six inches, seem to have what little advantage there is. To the objection which might be made against these dimensions, founded upon the inconveniences arising to the coach-maker in altering the routine of his business, he replies, it is certainly as easy to fix the splinter-bar under the futchells, as upon them; and I see no great outrage that would be done to appearance and fashion, if the buttons on which the traces are looped, were *under* the splinter-bar instead of being at the top. In these cases the draught would have all its mechanical advantages, and the horses would draw agreeably to their form and anatomy; the pole would have the same command of the carriage down hill, and the same command in turning, as in the present method.

Common experience will inform us, that when a horse is to convey a certain weight, he ought, that he may draw the better, to have a proportionable weight on his back or shoulders. A horse in a two-wheeled cart, in which there is a ton weight, when it is in equilibrio, will not be able to draw it; but when there are fifty or sixty pounds bearing on his back, he will draw it with ease. If it be two or three tons, when he bears one hundred or two hundred pounds on his back, he will be able to draw the load, because the wheels of a cart are very high.

When a horse draws hard, he bends forward, and brings his breast nearer the ground; and then, if the wheels be very high, he is pulling the carriage against the ground.

A horse, tackled in a waggon, will draw two or three tons weight, because the line of traction is below his breast.

It is very common, when one horse is drawing a heavy load, to see his fore-feet rise from the ground, and he will nearly stand an end. It is usual in this case to add a weight on his back, to keep his fore-feet down, by a person mounting on him, which will enable him to draw the load he could not move before.

The case is nearly the same in applying the strength of a man in wheeling a load in a wheelbarrow. When most of the load lies on the wheel, he will slip and not be able to get forward; but when bringing the weight nearer his arms, he will be able to drive it forward. In drawing a heavy garden-roll, if the axis of motion were even with that part of his body where his arms are extended, he could not be able to draw it along; but will draw it easily if the line of traction be low.

In a loaded cart which hangs nearly in equilibrio, if two men were to take it by the shafts, then they would not be able to move it; but one of them in the shafts, and the other behind the cart, pushing the breech upward as well as forward, he lays the load on the first man's back, and so pressing both the feet against the ground, they will easily draw the load.

In a long team, where only one hind horse bears on, if we take off half the number, and fix them to a lower point of traction, they will be able to move a much greater weight.

Sledges were probably the first machines used in carrying loads; we find them thus employed in Homer, in conveying wood for the funeral pile of Patroclus. There are some countries also, that preserve their use to this day. However, men early began to find how much more easily a machine could be drawn upon a rough road that run upon wheels, than one that thus went with a sliding motion. Though indeed, if all surfaces were smooth and even, bodies could be drawn with as much ease upon a sledge as upon wheels: and in Holland, Lapland, and other countries, they use sledges upon the smooth surface of the ice; for, as every surface upon which we travel is usually rough, wheels have been made use of, which rub less against the inequalities than sledges would do. In fact, wheels would not turn at all upon

ice, if it were perfectly smooth, since the cause of the wheels turning upon a common road is the obstacles they continually meet. For, if we suppose the wheels to be lifted from the ground and carried along in the air, the wheels in this case would not turn at all, for there would be nothing to put one part in motion rather than another; in the same manner, if they were carried along upon perfectly smooth ice, they would meet nothing to give a beginning to the rotatory motion, and all their parts would rest equally alike. But, if we suppose the wheel drawn along a common road, then the parts will receive unequal obstructions, for it meets with obstacles that retard it at bottom, therefore the upper part of the wheel, which is not retarded, will move more swiftly than the lower part, which is; but this it cannot do, unless the wheel moves round. And thus it is, that the obstacles in the rough road cause this rotatory motion in the wheel.

The utility of wheels arises therefore, from their turning upon their axes, the resistance arising from friction being very much diminished, and the draught thereby rendered more easy; and it will be found by experiment, that it requires considerably less force to draw a carriage when the wheels are free to turn about their axis, than when they are chained together and cannot turn. According to Helsham, a carriage with four wheels will be drawn with one fifth of the effort required for one that slides on the same surface in a sledge. From the foregoing experiment, it not only appears that the friction is very much lessened, but that this diminution does not arise from the wheels touching the plane in a few points, but from their rotation on their axis.

A sledge passing over a plane undergoes a friction, or rubbing of its parts against the plane equal to the distance through which it moves; but if an axis be applied whose circumference is six inches, and on that a wheel be placed whose circumference is eighteen feet, it is evident, that in moving the carriage eighteen feet over a plane, the wheels will make but one revolution; and, as there is no sliding of the parts between the plane and the wheels, but only a mere change of surface, by one part of the wheel rising and the other descending nearly perpendicular to the plane, no friction will take place there, the whole being transferred to the nave acting on the axis; which nave having made but one revolution in the same time, there has been only a sliding of the parts equal to the circumference of the hole in the nave, here supposed to be about six inches, so that the friction is lessened about as one to thirty-six; besides the advantage gained by confining it to so small a surface, whereby the parts are more easily kept smooth and fitted to each other, and substances applied and retained to lessen the remaining friction.

By the application of wheels to a carriage, the friction is lessened in the proportion of the diameters of the axis, and concave part of the nave, to those of the wheels.

When a carriage is drawn up hill, or any regular plane ascent without wheels, you have not only the friction to overcome, but the power must also be sufficient to overcome that proportion of the weight of the carriage, which the perpendicular part of the inclined plane bears to that proportion of the plane.

Wheels applied to a carriage moving up a regular plane of ascent appear only to act as removing the friction; for, though they may be considered as levers, yet, as each arm of the lever is lengthened in proportion to the size of the wheels, the power will be only augmented as far as the ascent can be considered as a mechanical power for raising the wheels, carriage, &c. to the top of the hill.

Large wheels have the advantage of small ones in overcoming obstacles, because they act as levers in proportion to their sizes. And in general the centre of gravity should be as near as may be to the axis of the wheel; and where safety is particularly considered, the nearer that centre is to the ground, the better.

If the suspension be below, and the body be turned forwards, as is the case with two-wheeled carriages descending hills, then will the greater part of the weight be thrown before the axis, and must be partly borne up by the horse that draws; in ascending, the same proportion will be thrown backwards, and tend to lift the animal. If the body be suspended above the centre of gravity, the disadvantages will be equal, but the effect will be reversed.

The latest experiments on this subject have been made by the Rev. Mr. Vince.

Mr. Vince, on Wheel Carriages on plane hard Ground.

If the wheels be all equal and narrow, it requires the same weight to draw the carriage, whether it be loaded before or behind.

If broad wheels be put on, of the same size and weight, it requires the same weight to draw the carriage as for the

narrow wheels, at whatever part it is loaded.

If two wheels be low, and two high, it requires a greater weight to draw the carriage than when all are high.

In this case it makes no sensible difference which go before. The common opinion, therefore, that the high wheels drive on the lower when they go forward, is not true.

If the wheels be all equal, it requires a greater weight to draw the carriage, the less the wheels are.

The disadvantage of small wheels arises from hence, that the resistance of the ground, which turns the wheels about, more easily overcomes the friction at the axle in a large than a small wheel, because it acts at a greater distance. For, the mechanical advantage of wheels is, that the resistance which must be overcome by a force more than equivalent to it, if the wheels could not turn, is overcome by a less force in the proportion of the radius of the wheel, to the radius of the axle, when the wheels do turn. Hence the disadvantage of laying the load upon the low wheels, as it increases the friction where there is the least power to overcome it. Where the load is but small, and consequently the friction but small, there is but a small difference between the small and large wheels; but when the load is great, the difference becomes considerable.

On hard Ground with Obstacles.

If W be the weight of the carriage, and the centre of gravity be in the middle; also if $r =$ the radius of the wheel, and $x =$ the height of the obstacle, then the power P acting parallel to the horizon, which is just sufficient to balance the carriage at the obstacle without drawing it over $= \frac{W \times \sqrt{(2rx - xx)}}{2r - 2x}$.

For the power may be conceived to be drawing a weight up an inclined plane, which is a tangent to the circle at the point where it touches the obstacle; and as when that end rises, the other rests upon the horizontal plane, the power has to elevate a weight only equal to $\frac{1}{2}W$.

Experiments of this kind are subject to inaccuracies which cannot be accounted for. The power will sometimes hang for some time without moving the carriage, and then it will suddenly draw the carriage over the obstacle. Sometimes there will be a difference of half an ounce out of about ten ounces in drawing the same carriage over the same obstacle, although every care is taken to have all the circumstances accurately the same. Many of the experiments, however, answer very nearly to the theory, nor do any of them differ from it very materially.

The use of high wheels in going over obstacles is very manifest from this proposition, and as carriages are continually going over obstacles, high wheels will always have the advantage. Moreover, in sinking into holes, they have a double advantage; first, they do not sink so deep as low ones would; and secondly, after sinking, they ascend again with less power. As, when the centre of gravity is in the middle of the carriage, the power has but half its weight to elevate in going over an obstacle; therefore, when the load is not in the middle, it throws the centre of gravity towards one end, and, therefore, when that end goes over an obstacle, the power has more than half the weight to raise, the pressure upon each wheel being inversely as the distance of the centre of gravity from them. Hence, every carriage should be loaded most towards the higher wheels, by which means less than half the weight will be thrown upon the lower wheels, and thus each pair of wheels may be made to require the same power to draw them over an obstacle. The same power, however, that may be necessary for one obstacle, will not be sufficient for another.

If the height of the obstacle be inconsiderable in respect to the radius of the wheel, which is the case with the common obstacles, as stones, &c. which carriages usually meet with, then $P = W \times \sqrt{\frac{2r}{x}}$. Now as each pair of wheels has the same obstacles to go over, x is given, and that P may be given, or that it may require the same power for each pair, W must vary as $\sqrt{r}$; now the weight supported by each wheel is inversely as its distance from the centre of gravity. Hence, to overcome small obstacles, the distance of the centre of gravity from the great wheels : its distance from the small : : the square-root of the radius of the small wheel : the square-root of the radius of the large wheel. The diameters of the wheels of a common waggon are about five feet eight inches, and four feet eight inches, and the distance of the wheels, when narrow, about six feet six inches; hence the centre of gravity of the load of a waggon ought to be about three feet six inches nearer to the higher than to the lower wheels. For a broad wheel waggon, where the distance of the wheels is about seven feet ten inches, the centre of gravity ought to be about four feet

two inches nearer to the higher than to the lower.

It appears also that when W and x are given, and x is very small, P varies inversely as the square-root of the radius of the wheel. Hence the advantage of a wheel to overcome a small obstacle varies as the square-root of the radius of the wheel. This resistance of the obstacle causes the wheel to turn, but this resistance is not friction; the friction arises from the rubbing of the parts of one body against those of another, whereas where the wheel only turns upon a point, the friction therefore only takes place at the axle, where the parts rub one against another. There is therefore no friction at the ground, unless when the wheels slide, which is the case when they are chained together, as is frequently done to prevent them from running too fast down hill.

Upon Sand.

It requires a less force to draw a narrow than a broad wheel carriage upon sand.

The disadvantage of the broad wheels seems to arise from their driving the sand before them.

If two wheels be high and two low, it requires a greater force to draw the carriage than when all the wheels are high.

If all the wheels be low, it requires a greater force to draw the carriage than in the last case.

In all these cases it requires less force to draw the carriage, when loaded behind than before.

Whatever permits the load to rise gradually over an obstacle, without obstructing the velocity of the carriage, will tend to facilitate its draught, and the application of springs has this effect to a very considerable degree; the same weight of four pounds, being drawn over the same obstacles, when springs were put between the load and the carriage, by four pounds instead of fourteen. This remarkable difference, points out the great advantage of springs in rough roads, an advantage which might be obtained for heavy waggons, as well as for other carriages, by a judicious application of the same means.

It appears from the Memoirs of the French Academy, that the idea of applying springs to carriages, had occurred to M. Thomas, in the year 1703, who has given a drawing of a carriage constructed upon this principle, many years before it was attempted to be put in execution. So little expectation had he of success, that he expressly mentions it as a theory, which could not be reduced to practice; he had, however, no notion of applying springs to faciliate the draught, but merely for the convenience of the rider; and I apprehend that it is not at present commonly imagined, that springs are advantageous for this purpose; nor would it at first sight appear credible, that, upon a rough paved road, such as are common in Cheshire, and other parts of England, a pair of horses could draw a carriage mounted upon springs with greater ease and expedition, than four could draw the same carriage, if the springs and braces were removed, and the carriage bolted fast down to the perch.

The reasons why springs so much facilitate the draught of carriages, seems to be, not only that they allow the wheels to pass more gradually over the obstacles, but that by their elasticity, they make the carriage bound upwards every moment for a small way; thus its gravity is for that moment in a great measure counteracted, and the progressive motion which it has already acquired, is at liberty to act more freely in pushing it forward; for were it possible very suddenly to take away the horses from a carriage mounted on springs, and moving with a considerable velocity, it would continue for some time to move of itself; the weight in this case acting as a fly, upon any mechanical engine, by means of which the machine accumulates a certain quantity of power, and will keep itself in motion for a considerable time after the hand is taken away from it. The weight of all carriages, indeed, has some effect of this kind, otherwise the draught would require an intolerable exertion of strength: and it is to be observed, that this tendency to proceed in the direction in which it is once set a going, is remarkable in all great quantities of matter, and very perceptible even when weights are pulled directly upwards; for in raising great weights by a crane, the burden is lifted with considerable more ease, when near the top than at the bottom, even after making every necessary allowance for the weight of the rope.

WATER.—It is scarcely necessary to give any definition or description of this universally known fluid. It is a very transparent fluid, possessing a moderate degree of activity, with regard to organized substances, which renders it friendly to animal and vegetable life, for both which it is indeed indispensably necessary.—Hence it acts but slightly on the organs of sense, and is therefore said to have neither taste nor smell.

Water does not possess any considerable density. Most mineral substances are

heavier than this fluid, and among organized matters, there are perhaps none, except oils, and the products of art, which, if lighter than water, do not owe this property to their mechanical structure. At a moderate temperature water assumes the solid state, or freezes; and at a degree of heat far below that required to fuse, any of the simple metals but mercury, its internal parts assume the elastic state, and fly off with ebullition. The freezing and boiling points of water, are assumed at the standards for admeasurements of heat. See THERMOMETER. Its weight is also used as the standard for specific gravities: see SPECIFIC GRAVITY, also ALCOHOL.

Its capacity for heat is taken as the standard of the specific heats of bodies. And in a word, the solubility or insolubility of bodies in this fluid, composes a large part of the science of chemistry

When water is cooled gradually, it contracts in its dimensions, till within eight degrees of freezing, and then expands, till it begins to assume the solid state.—Congealed water or ice is considerably larger in its dimensions than water, upon which it therefore floats. The expansion of ice, at the time of its formation, is made with such force, as to burst the strongest metallic vessels. The assumption of the solid state in water is effected, like other crystallizations, under a symmetrical figure. The parts which become solid first by freezing, have the form of daggers, crossing each other at angles of 60 degrees. The crystallization of ice is also seen to advantage in snow and hoar frost, which are of the nature of the vegetation of salts, though probably they may not require the co-operation of light.

Steam, or the vapour of water, possesses a strong power of expansion, which is greater the higher its temperature. This power has within the last century, been very advantageously applied to mechanical purposes. The vapour of water is more expansible in the same weight and temperature, than air; whence the steam in half-filled vessels, always occupies the upper place, and moist air is less heavy than dry. Common air imbibed by water, and afterwards expelled again, is found to contain somewhat more of oxygen than before. It follows therefore, that the vital part of the atmosphere, is more disposed to combine with water than the azotic part. This effect is remarkably perceived in fogs, which commonly exhibit the peculiar smell of burned gunpowder or nitrogen gas; and must be ascribed to a proportion of the oxygen having combined with the water of the fog.

The eolipile is a copper vessel or globe, with a small apperture on one side. If this be heated and then immersed in water, it will be partly filled by the pressure of the atmosphere; and if this water be then made to boil, the steam will issue out with considerable violence, and excite a fire in the same manner as bellows. This has been thought to indicate a decomposition of the water; but it is not the steam which produces this effect, but the air it carries with it by its mechanical impulse; for if the nozzle of an eolipile be inserted directly into the fire, without leaving any space for the interposition of a body of air, it will not excite but extinguish the fire, as Dr. Lewis proved by experiment.

Water is not only the common measure of specific gravities, but the tables of this element may be usefully employed in the admeasurement of irregular solids; for one cubic foot is very nearly equal to 1000 ounces avoirdupois. The numbers of the table denoting the specific gravities, do therefore denote likewise the number of ounces avoirdupois, in a cubic foot of each substance.

Native water is seldom, if ever, found perfectly pure. The waters that flow within, or upon the surface of the earth, contain various earthy, saline, metallic, vegetable, or animal particles, according to the substances, over or through which they pass. Rain and snow waters are much purer than these, although they also contain whatever floats in the air, or has been exhaled along with the watery vapours.

The purity of water may be known by the following marks of the properties of pure water:

1. Pure water is lighter than water that is not pure; for not only the substances usually dissolved in water, are heavier than water, but also the specific gravity, of a solution of any of these substances in water, is generally greater than the intermediate specific gravity of the water, and of that substance.

2 Pure water is more fluid than water that is not pure; hence it is said to occasion a louder sound, when poured from one vessel into another.

3. It has no colour, smell or taste.

4. It wets more easily than the waters, containing metallic and earthy salts, called hard waters, and feels softer when touched.

5. Soap, or a solution of soap in alcohol, mixes easily and perfectly with it.

6. It is not rendered turbid by adding to it a solution of gold in aqua regia, or a solution of silver, or of lead, or of mer-

cury, in nitric acid, or a solution of acetate of lead in water.

The action of water upon various saline substances, or their respective solubilities, constitutes an object of great value, in the science of chemistry. This has been occasionally shown under the respective articles. But as these results may be of value seen all together, I shall here insert three tables from the Notes on Macquer's Dictionary.

The following table shows the quantities of the saline substances, that could be dissolved in an ounce of water, with the heat of fifty degrees of Fahrenheit's scale, according to experiments made by Mr. Spielmann. Instit. Chemiæ, p. 48.

	Grains.
Acetate of potash	470
Salt of Sedlitz	384
Sulphate of magnesia	324
Subcarbonate of potash	240
Neutral tartrite of potash	212
Sulphate of zinc	210
Sal gem	200
Subcarbonate of soda	200
Sal ammoniac	176
Common salt	170
Sulphate of soda	168
Salt of Lorraine	168
Muriate of potash	160
Tartrite of soda	137
Sulphate of copper	124
Sulphate of iron	80
Purified nitre	60
Sal polychrest of Glaser	40
Sulphate of potash	30
Corrosive muriate of mercury	30
Borax	20
Alum	14
Succinc acid	5
Arsenious acid	5
Crude tartar	4
Cream of tartar	3

Water when saturated with one salt is capable of dissolving a considerable portion of another salt; and when saturated with this also, it may still dissolve a third, a fourth, or more salts. Thus, according to Neumann, four ounces of water that have been saturated with a drachm and a few grains of alum, will still dissolve five drachms of nitre, then half an ounce of sulphate of iron, six drachms of common salt, three drachms of neutral tartrite of potash, and five drachms of sugar. In the same manner also, four ounces of water, saturated with half an ounce of nitre, will dissolve half an ounce of sulphate of zinc, six drachms of common salt, six drachms of sal ammoniac, half an ounce of neutral tartrite of potash; and after all these an entire ounce of sugar.

Mr. Eller has published an account of his experiments, concerning the solutions of different salts in the same water. See Mem. of the Acad. of Berlin, for the year 1750.

Water has long been considered, as an elementary or simple substance. But the chemists of our own time, in their researches into the nature of elastic fluids, have obtained water in circumstances where there is the highest reason to conclude, that it is produced by combination; and in other experiments its decomposition into two principles, namely, oxygen and hydrogen, is judged to take place.

The powers of nature, which are ever the same, and are continually performing their operations before us, whether we understand them or not, often present facts of the utmost value and importance, which we overlook, or regard with indifference. Hence it happens, that, when an enlightened observer makes any discovery, it is almost always remarked, that somebody has seen the fact before him, or given some confused hints respecting its theory. It is evident, however, that the first discoverer, if there be any merit in discovery, is not the man who finds the treasure, and supposes it to be none, but he who is conscious of its value, and applies it to use. On these principles it is, that the claims of the discoverers of the composition of water must be estimated. The facts appear to be as follows:

Previous to the month of October, 1776, the celebrated Macquer, assisted by Mr. Sigaud de la Fond, made an experiment by burning hydrogen gas in a bottle, without explosion, and holding a white china saucer over the flame. His intention appears to have been that of ascertaining whether any fuliginous smoke was produced; and he observes, that the saucer remained perfectly clean and white, but was moistened with perceptible drops of a clear fluid, resembling water, and which in fact appeared to him and his assistant, to be nothing but pure water.

In the month of September, 1777, Messrs. Bucquet and Lavoisier, not being acquainted with the fact, which is incidently and concisely mentioned by Macquer, made an experiment to discover what is produced by the combustion of hydrogen. They fired five or six pints of hydrogen, in an open and wide-mouthed bottle, and instantly poured two ounces of lime-water through the flame, agitating the bottle, during the time the combustion lasted. The result of this expe-

riment showed, that carbonic acid was not produced.

Before the month of April, 1781, Mr. John Waltire, encouraged by Dr. Priestley, fired a mixture of common air and hydrogen gas, in a close copper vessel, and found its weight diminished. Dr. Priestley, likewise, before the same period, fired a like mixture of hydrogen and oxygen gas, in a closed vessel, Mr. Warltire being present. The inside of the vessel, though clean and dry before, became dewy, and was lined with a sooty substance. These experiments were afterwards repeated by Mr. Cavendish and Dr. Priestley, and it was found, that the diminution of weight did not take place, neither was the sooty matter perceived. These circumstances, therefore, must have arisen from some imperfection in the apparatus or materials, with which the former experiments were made.

It was in the summer of the year 1781, that Mr. Henry Cavendish was busied in examining what becomes of the air lost by combustion, and made those valuable experiments, which were read before the Royal Society on the 15th of January, 1784. He burned 500,000 grain measures of hydrogen gas, with about 2½ times the quantity of common air, and by causing the burned air to pass through a glass tube of 8 feet in length, 135 grains of pure water were condensed. He also exploded a mixture of 19,500 grain measures of oxygen gas, and 37,000 of hydrogen, in a close vessel. The condensed liquor was found to contain a small portion of nitric acid, when the mixture of the air was such, that the burned air still contained a considerable proportion of oxygen. In this case it may be presumed, that some of the oxygen combines with a portion of nitrogen present. This great philosopher, who may be considered as the true discoverer, of the composition of water, appears to think with Mr. Watt, that in those experiments of Dr. Priestley, wherein the sulphuric and nitric acids, seemed to be converted into oxygen, the acids served only to decompose the water, by depriving it according to the theory of that day, of its phlogistic or combustible part; but he thinks it unnecessary to include the consideration of elementary heat, as Mr. Watt does, because in his opinion it is more likely, that there is no such thing, and that the bringing the consideration forward, in every chemical experiment, in which increase or diminution of heat takes place, might occasion more trouble and perplexity than it is worth.

In the mean time, Mr. Lavoisier continued his researches, and during the winter of 1781, 1782, together with Mr. Gingembre, he filled a bottle of six pints with hydrogen, which being fired, and two ounces of lime-water poured in, was instantly stopped with a cork, through which a flexible tube communicating with a vessel of oxygen, was passed. The inflammation ceased, except at the orifice of the tube, through which the oxygen was pressed, where a beautiful flame appeared. The combustion continued a considerable time, during which the lime-water was agitated in the bottle. Neither this, nor the same experiment repeated with pure water, and with a weak solution of alkali instead of lime-water, afforded the information sought after, for these substances were not at all altered.

The inference of Mr. Warltire, respecting the mosture on the inside of the glass, in which Dr. Priestley first fired hydrogen and common air, was, that these airs by combustion deposited the moisture they contained. Mr. Watt, however, inferred from these experiments, that water is a compound of the burned airs, which has given out their latent heat by combustion, and communicated his sentiments to Dr. Priestley, in a letter dated April 26, 1783, and he concludes, that in every case where oxygen gas was produced, water had been decomposed by the use of some substance, which had a stronger attraction to its phlogiston than is possessed by the oxygen gas, which is therefore set at liberty. He repeated some experiments, particularly with a view to decide this point; and in several of them the quantity of oxygen gas, added to the acid which came over, greatly exceeded the original weight of acid employed. He dissolved magnesia, calcareous earth, and minium, respectively, in pale nitric acid, and on distilling to dryness, found nearly the whole of the nitric acid in the retort, highly saturated with nitrogen. From common nitre, the oxygen gas was sixteen times the weight of the nitric acid which was missing. Mr. Watt has therefore a claim to the merit of a discoverer, with regard to the composition of water, and has the advantage of priority, in the discovery of its decomposition.

It does not appear, that the composition of water was known or admitted in France, till the summer of 1784, when Mr. Lavoisier and Mr. de la Place, on the 24th of June, repeated the experiment of burning hydrogen and oxygen in a glass vessel over mercury, in a still greater quantity than had been burned by Mr.

Cavendish. The result was nearly five gros of pure water. Mr. Monge made a similar experiment at Paris, nearly at the same time, or perhaps before.

The theory which was proposed and explained by Mr. Lavoisier, wherein such phenomena as chemists have usually accounted for by the disengagement or transition of phlogiston are explained, merely by the engagement or contrary transition of oxygen gas, or its base, by him called the oxygenous or acidifying principle, and it received a great accession from the discovery of the composition of water. For it was easy to attribute the hydrogen, which is disengaged in many processes, to the decomposition of water, which is undoubtedly present in most of them ; instead of supposing it to come from such bodies, as former chemists had imagined to contain the principle of inflammability. In the month of September, 1783, Mr. de la Place communicated to Mr. Lavoisier, his thoughts on the decomposition of water, which from Mr. Lavoisier's former experiments, he concluded to take place in metallic solutions ; and these reasons, added to Mr. Lavoiser's own reflections, induced him to pursue the subject by a new series of experiments.

This assiduous and accurate philosopher was the first, who placed a quantity of iron filings, and pure water in the upper part of a vessel, inverted over mercury, and observed, that the iron became oxided, hydrogen being at the same time disengaged, the water being, as he says, truly decomposed. He then proceeded, in conjunction with Mr. Meusnier, to pass the steam of water, through a red-hot iron tube, and found that the iron was oxyded, and hydrogen disengaged ; and the steam of water being passed over a variety of other combustible or oxydable substances, produced similar results, the water disappearing, and hydrogen being disengaged. These capital experiments were accounted for by Mr. Lavoisier, by supposing the water to be decomposed into its component parts, oxygen and hydrogen, the former of which unites with the ignited substance, while the latter is disengaged.

The grand experiment of the composition of water by Fourcroy, Vauquelin and Seguin, was begun on Wednesday, May 13, 1790, and was finished on Friday the 22d of the same month. The combustion was kept up 185 hours with little interruption, during which time the machine was not quitted for a moment. The experimenters alternately refreshed themselves when fatigued, by lying for a few hours on mattresses, in the laboratory.

To obtain the hydrogen, 1st, Zinc was melted and rubbed into a powder, in a very hot mortar. 2d. This metal was dissolved in concentrated sulphuric acid, diluted with seven parts of water. The air procured, was made to pass through caustic alkali. To obtain the oxygen, two pounds and an half of crystallized hyperoxymuriate of potash, were distilled, and the air was transferred through caustic alkali.

Upon the whole, as the fidelity of these philosophers, cannot be suspected, as the product of water, so remarkably coincides with the weight of the air which was burned, as there was no vestige of acid produced, and the residue of azotic air was not greater than might be accounted for, on the supposition of original impurity ; the experiment may be admitted to prove that oxygen and hydrogen, in certain proportions, do unite at the temperature of moderate combustion, and form water. Whether these principles may in any other proportion, or at any different temperature, or by any order of arrangement as to primary and secondary composition, produce any other result, are circumstances which, for any thing we know, are within the limits of possibility ; and it does not appear that this really happens.

Subsequent to the alleged decomposition of water, by means of iron, Messrs. Paets Van Trootswyk and Deiman, gave an account of some experiments, by which they produced gradually, a quantity of air from water, and instantly caused it to disappear. Their own account is inserted in the Journal de Physique, for November 1789. They filled with distilled water a glass tube, one-eighth of an inch in diameter, and twelve inches long, English measure. One extremity of this tube, was hermetically sealed ; but at the time of sealing a small gold wire was inserted, and by that means passed through the glass into the tube, for the length of one inch and a half. At the distance of five-eighths of an inch from the end of this wire, another wire was placed in the tube, which came out at the open end into a small vessel of distilled water, in which that end was immersed. For the purpose of passing the electric commotion through these wires, and consequently through the water between them, the sealed end of the tube with its wire, was applied to an insulated copper ball, at a certain distance from the prime conductor, of their electrical machine, at the same time that

the extremity of the other wire, which passed through the vessel filled with water, was made to communicate with the external surface, of an electrical jar of one foot square, the knob of which touched the prime conductor.

When the electric shock was passed through the water, with a very small interval, between the copper ball and the conductor, nothing of consequence happened; but when the distance and consequently the shock was increased, so that the extremity of each wire, became tipped with light, a great many of very minute bubbles of air, were produced at each commotion, which had the appearance of a continual flux between the two extremites. This production of air was more considerable, and the bubbles at the same time larger, when the distance between the copper ball and the prime conductor was increased, so that sometimes a small spark was seen, to pass from the upper wire into the water. The air obtained in this manner, occupied the upper part of the tube, and gradually increased in quantity, by the continuance of the process, until the water became depressed, below the extremity of the upper wire. At this instant the electric spark, which passed through a small portion of the air, from the upper wire to the water, set fire to the air, precisely in the same manner, as happens with a mixture of hydrogen and oxygen, and the whole disappeared, excepting a very small residue. This residue being taken out, the experiment was again repeated several times with the same result; excepting only, that the residue of the air after each inflammation appeared to be less and less.

Several chemists found it difficult to repeat this experiment, on account of the facility, with which the electric shock from wires under water, breaks the containing tube. To prevent this effect, these philosophers were careful, that the distance between the two wires, should be too great for a spark to pass, from the one to the other. And Dr. Pearson, before whom the experiments were repeated by Mr. Cuthbertson, asserts, that the discharges were interrupted; by which word electricians commonly understand, that part of the circuit is an imperfect conductor. It is probably of consequence, that the stream of electricity should be kept up almost steadily, when the expansion from the extricated bubbles has once been produced. The plate-machine of thirty-two inches in diameter, used by these philosophers, was so powerful, as to occasion nearly two full explosions from a square foot of glass, in each turn. The smaller shocks here mentioned, must therefore have been extremely numerous.

Since the discovery of galvanism, the apparent decomposition of water, has been effected by its means, with more singular phenomena. If two wires, about an inch distant, be inserted in a tube 0.2 of an inch in diameter, and these wires be made to communicate with the opposite extremities of a galvanic pile or trough, water in the tube will be decomposed rapidly. The effect takes place, even if the wires be several inches distant, when the pile is powerful. But what is very remarkable, the decomposition may be effected in two different tubes, the wire from one extremity of the pile being introduced into one, and that from the opposite extremity into the other; provided a communication be established by another wire, or good conductor, between the water in the two tubes: and the air evolved from the water in one of the tubes, is hydrogen only, both of them nearly pure. The hydrogen uniformly appears in the tube, communicating with what is commonly considered as the negative end of the pile, and the oxygen at the positive end.

It has been asserted by some, that the water, instead of being decomposed into oxygen and hydrogen, is converted into an acid and an alkali. This acid is said to be the muriatic, though some assert it to be the nitric; and the alkali according to some is soda.

Dr. Priestley published in a separate pamphlet, experiments on the generation of air from water.

Water we have said, under the ordinary atmospheric pressure, is converted into steam, at 212° Fahr. of temperature, and by so doing, it expands to about 1800 times its former bulk: the elastic force which it thus acquires is very considerable, and constitutes the moving power of that most important machine, the steam engine. Steam readily and entirely condenses into water as it cools, and it is in this way, that is by distillation, that pure water is obtained; for the most delicate chemical uses, the distillation must be carried on in glass vessels, and even with every possible precaution, it is by no means easy to obtain this fluid of absolute purity.

It does not appear that mere heat is capable of effecting any change in water, for steam may be passed through a red-hot glass tube, and be condensed at the other end again into pure water.

A considerable affinity subsists between water and atmospheric air; for if this fluid recently distilled, be exposed for a

few days to the air, and afterwards be boiled or subjected to the action of the air-pump, a considerable quantity of bubbles of gas will be disengaged ; there still remains a portion combined with the water, which it is very difficult to get rid of, even by long boiling.

Oxygen gas is absorbed by water, in preference to atmospheric air, and by means of strong agitation and pressure, according to the experiments of M. Paul, of Geneva, 100 cubic inches of this fluid, may be made to take up 50 cubic inches of oxygen gas, 33 cubic inches of hydrogen, and 66 cubic inches of carburetted hydrogen.

Water is capable of combining with, and dissolving the acids, the alkalies and alkaline earths, and all the compound salts ; with several of these substances it unites in two proportions, forming in one case a solid, and in the other case a fluid compound ; thus if calcined gypsum, or barytes, or lime, or sulphat of soda, are mixed with a certain proportion of water, the resulting mass is quite as solid as before, and during this first combination, a quantity of heat is constantly extricated, but if to the salts thus saturated more water is added, solution takes place, and cold is generated. From this solution, the salt may again be in most cases procured, by evaporating and cooling, in a crystalline form, in which, though solid, it is still saturated with water: this proportion of water appears to be necessary, to the crystalline form of the salt, and hence it is usually called its water of crystallization ; by a dry heat it is driven off, and the salt alone remains in a pulverulent or amorphous state.

A considerable affinity subsists between water and alcohol : if determinate bulks of these two fluids be mixed together, the resulting mass will be found to have a specific gravity, superior to that of the mean of the ingredients, and a sensible degree of heat will be disengaged during mixture : there appears however, to be no point of saturation, at which they will combine together in all proportions. Resins and most other substances insoluble in water, but soluble in alcohol, are precipitated from their solution, by the addition of the former fluid : as on the other hand, all salts that are soluble in water, and not in alcohol are precipitated by means of this, from their watery solution.

Ether and water are capable of uniting in two different proportions. If equal bulks of the two fluids are shaken together, and then allowed to rest for a few seconds, the mass will divide into two distinct liquids, of which the upper and lighter is ether, holding a little water, and the lower and denser, is water combined with a little ether.

None of the simple combustibles appear to be soluble in water, nor have they any marked action on this fluid, at the common temperature.

Of the metallic substances, iron, zinc, tin, and manganese decompose water by the assistance of heat, hydrogen gas being produced, and the metals being reduced to the state of oxyd. Gold, silver, platina, and copper have no action on water even at a red heat ; the effect of the other metals has not been examined.

The proportion of the ingredients that compose water, as deduced from the preceding experiments, are according to

Lavoisier . . .	15.	of Hydrogen to	85. of Oxygen
Le Fevre Gineau . .	15.2		84.8
Vauquelin & Fourcroy .	14.33		85.66

Water is known to become putrid, when kept in casks, as in sea-voyages. This is owing to the matter it takes up from the wood, and may be prevented by charring the inside of the cask.

WATER OF CRYSTALLIZATION. Many salts require a certain proportion of water, to enable them to retain the crystalline form, and this is called their water of crystallization. Some retain this so feebly, that it flies off on exposure to the air, and they fall to powder. These are the efflorescent salts. Others have so great an affinity for water, that their crystals attract more from the air, in which they dissolve. These are the deliquescent.

The proportion of this water in various salts, likewise differs greatly ; some having but a very small quantity, others sufficient to hold the whole of the salt in solution, by the assistance of heat.

WATERS (MINERAL.) The examination of mineral waters, with a view to ascertain their ingredients, and thence their medical qualities, and the means of compounding them artificially, is an object of considerable importance to society. It is likewise a subject which deserves to be attended to, because it af-

fords no mean opportunity for the agreeable practice of chemical skill. But this investigation is more especially of importance to the daily purposes of life, and the success of manufactures. It cannot but be an interesting object, to ascertain the component parts and qualities of the waters daily consumed by the inhabitants of large towns and vicinities. A very minute portion of unwholesome matter, daily taken, may constitute the principal cause, of the differences in salubrity, which are observable in different places. And with regard to manufactures, it is well known to the brewer, the paper-maker, the bleacher, and a variety of other artists, of how much consequence it is to them, that this fluid should either be pure, or at least not contaminated with such principles, as tend to injure the qualities of the articles they make. This analysis has accordingly employed the attention of the first chemists. Bergman has written an express treatise on the subject, which may be found in the first volume of the English translation of his Essays. Fourcroy has written largely on this subject. Chaptal in his Elements of Chemistry, has given a very concise and perspicuous account of mineral waters, and the methods of examining them. And more recently, Kirwan has published an octavo volume, on the analysis of waters.

The topography of the place where these waters rise, is the first thing to be considered. By examining the ooze formed by them, and the earth and stones through which they are strained and filtered, some judgment may be formed of their contents. In filtering through the earth, and meandering on its surface, they take with them particles of various kinds, which their extreme attenuation, renders capable of being suspended in the fluid, that serves for their vehicle.—Hence, we shall sometimes find in these waters, siliceous, calcareous, or argillaceous earth, and at other times, though less frequently, sulphur, magnesian earth, or from the decomposition of carbonated iron; ochre!

The following are the ingredients that may occur in mineral waters:

1. Air is contained in by far the greater number of mineral waters: its proportion does not exceed one-twenty-eighth, of the bulk of the water.

2. Oxygen gas was first detected in waters by Scheele. Its quantity is usually inconsiderable: and it is incompatible with the presence of sulphuretted hydrogen gas, or iron.

3. Hydrogen gas was first detected in Buxton water by Dr. Pearson. Afterwards it was discovered in Harrowgate (England) waters, by Dr. Garnet, and in those of Lemington Priors, by Mr. Lambe.

4. Sulphuretted hydrogen gas, constitutes the most conspicuous ingredient in those waters, which are distinguished by the name of hepatic, or sulphureous.

The only acids hitherto found in waters, except in combination with a base, are the carbonic, sulphurous, and boracic.

5. Carbonic acid was first discovered in Pyrmont water, by Dr. Brownrigg. It is the most common ingredient in mineral waters, 100 cubic inches of the water, generally containing from 6 to 40 cubic inches of this acid gas. According to Westrumb, 100 cubic inches of Pyrmont water, contains 187 cubic inches of it, or almost double its own bulk.

6. Sulphureous acid has been observed in several of the hot mineral waters in Italy, which are in the neighbourhood of volcanoes.

7. The boracic acid has also been observed in some lakes in Italy.

The only alkali which has been observed in mineral waters, uncombined, is soda; and the only earthy bodies are silex and lime.

8. Dr. Black detected soda in the hot mineral waters and Geyser and Rykum in Iceland; but in most other cases the soda is combined with carbonic acid.

9. Silex was first discovered in waters by Bergman. It was afterwards detected in those of Geysser and Rykum by Dr. Black, and in those of Carlsbad by Klaproth. Hassenfratz observed it in the waters of Pougues, as Breze did in those of the Pu. It has been found also in many other mineral waters.

10. Lime is said to have been found uncombined in some mineral waters; but this has not been proved in a satisfactory manner.

The only salts hitherto found in the mineral waters are the following sulphates, nitrates, muriates, carbonates and borates; and of these the carbonates and muriates occur, by far most commonly, and the borates and nitrates most rarely.

11. Sulphate of soda or Glauber salt, is not uncommon, especially in those mineral waters, which are distinguished by the epithet saline.

12. Sulphate of ammonia is found in mineral waters near volcanoes.

13. Sulphate of lime is exceedingly common in water. Its presence seems to have been first detected by Dr. Lister, in 1682.

14. Sulphate of magnesia or Epsom

salt, is almost constantly an ingredient in those mineral waters which has purgative properties. It was detected in Epsom waters, in 1610, and in 1696, Dr. Grew published a treatise on it.

15. Alum is sometimes found in mineral waters, but it is exceedingly rare.

16. Sulphate of iron occurs sometimes in volcanic mineral waters, and has even been observed in other places.

17. Sulphate of copper, is only found in the waters which issue from copper mines.

18. Nitre has been found in some springs in Hungary, but it is exceedingly uncommon.

19. Nitrate of lime was first detected in water, by Dr. Home of Edinburg, in 1756. It is said to occur in some springs in the sandy deserts of Arabia.

20. Nitrate of magnesia is said to have been found in some springs.

21. Muriate of potash is uncommon; but it has lately been discovered in the mineral springs of Uhleaborg in Sweden, by Julin.

22. Muriate of soda or common salt, is so extremely common in mineral waters, that hardly a single spring has been analized without detecting some of it.

23. Muriate of ammonia is uncommon, but it has been found in some mineral springs in Italy, and in Siberia.

24. Muriate of barytes is still more uncommon, but its presence in mineral waters, has been announced by Bergman.

25 and 26. Muriates of lime and magnesia, are common ingredients.

27. Muriate of alumine has been observed by Dr. Withering, but it is very uncommon.

28. Muriate of manganese was mentioned by Bergman, as sometimes occurring in mineral waters. It has lately been detected by Lambe in the waters of Lemington Priors, but in an extremely limited proportion.

29. The presence of carbonate of potash in mineral waters, has been mentioned by several chemists: if it do occur, it must be in a very small proportion.

30. Carbonate of soda, is perhaps, one of the most common ingredients of these liquids, if we except common salt and carbonate of lime.

31. Carbonate of ammonia has been discovered in waters, but it is uncommon.

32. Carbonate of lime is found in almost all waters, and is usually held in solution, by an excess of acid. It appears from the different experiments of chemists, as stated by Mr. Kirwan, and especially from those of Berthollet, that water saturated with carbonic acid, is capable of holding in solution, 0.002 of carbonate of lime. Now water saturated with carbonic acid, at the temperature of 50° Fahr. contains very nearly 000.2 of its weight of carbonic acid. Hence it follows, that carbonic acid, when present in such quantity as to saturate waters, is capable of holding its own weight of carbonate of lime in solution. Thus we see 1000 parts by weight of water, when it contains two parts of carbonic acid, is capable of dissolving two parts of carbonate of lime. When the proportion of water is increased, it is capable of holding the carbonate of lime in solution, even when the proportion of carbonic acid, united with it, is diminished. Thus 24.000 parts of water are capable of holding two parts of carbonate of lime in solution, even when they contain only one part of carbonic acid. The greater the proportion of water, the smaller proportion of carbonic acid is necessary to keep the lime in solution; and when the water is increased to a certain proportion, no sensible excess of carbonic acid is necessary. It ought to be remarked also, that when water is increased to a certain proportion, no sensible excess of carbonic acid is necessary. It ought to be remarked further that water, however small a quantity of carbonic acid it contains, is capable of holding carbonate of lime in solution, provided the weight of the carbonic acid present, exceed that of the lime. These observations apply equally to the other earthy carbonates, held in solution by mineral waters.

33. Carbonate of magnesia is also very common in mineral waters, and is almost always accompanied by carbonate of lime.

34. Carbonate of alumine is said to have been found in waters, but its presence has not been properly ascertained.

35. Carbonate of iron is by no means uncommon, indeed it forms the most remarkable ingredient in these waters, which are distinguished by the epithet of chalybeate.

36. Borax exists in some lakes in Persia and Thibet, but the nature of these waters has not been ascertained.

37 and 38. The hydro-sulphurets of lime and of soda, have been frequently detected in those waters, which are called sulphureous, or hepatic.

Mr. Westrumb says, that all sulphureous waters, contain more or less hydrosulphuret of lime.

To detect this, he boiled the mineral water, excluding the contact of atmospheric air, to expel the sulphuretted hy-

drogen gas, and carbonic acid. Into the water thus boiled, he poured sulphuric acid, when more sulphuretted hydrogen gas was evolved, and sulphate of lime was thrown down: fuming nitric acid, which separated from it sulphur: and oxalic acid, which expelled sulphuretted hydrogen, and formed oxalate of lime. The water evaporated in open vessels, let fall sulphate of lime, and gave out sulphuretted hydrogen gas.

To ascertain the quantity of sulphuretted hydrogen gas, and carbonic acid, Mr. Westrumb proceeded as follows: He introduced the sulphureous water into a mattras, till it was filled to a certain point, which he marked: fitted to it a curved tube, which terminated in a long cylinder; filled this cylinder with lime-water for the one experiment, and with acetate of lead, with excess of acid for the other; luted the apparatus, and boiled the water till no more gas was expelled. When the lime-water is used, carbonate of lime is precipitated in the proportion of 20 grains to every 10 cubic inches of carbonic acid gas; when the solution of acetate of lead, hydro-sulphuret of lead, is thrown down in the proportion of 19 grains to 10 cubic inches of sulphuretted hydrogen gas.

Another observation, not less remarkable, relates to sulphuretted nitrogen gas.

It is known, that Dr. Gimbernat, a Spanish chemist, asserts, that the thermal waters of Aix-la-Chapelle contain sulphuretted nitrogen gas. Mr. Schaub too says, that he has obtained it from the sulphureous waters, of Nenndorf in Hesse. The following characters are ascribed to this gas:

1. In smell it resembles sulphuretted hydrogen.

2. It is not decomposable by carbonic acid.

3. It is not inflammable.

4. It will not contain combustion.

5. It is not decomposable by nitrous acid.

6. It is decomposed by concentrated nitric acid, which separates from it sulphur.

7. It decomposes metallic solutions, and forms sulphurets.

8. It has a great affinity for water, from which it is only separable by long boiling.

But Mr. Westrumb has found, that sulphuretted hydrogen gas, when washed with milk or lime, if passed through lime diluted with water, acquires all the properties here mentioned. Whether the sulphuretted hydrogen gas be obtained from sulphureous waters, or prepared artificially, the same phenomena take place. If the milk of lime be taken from it by an acid, sulphuretted hydrogen is disengaged, which is inflammable, and possesses the usual properties. Sulphuretted hydrogen gas, therefore, is a product of the operation. Mr. Westrumb, however, is in doubt, whether this new gas be produced by the action of quicklime on sulphuretted hydrogen, or whether the sulphuretted hydrogen gas contain sulphuretted nitrogen.

A third observation, not less interesting, is the presence of carbon and carburetted substances in sulphureous mineral waters.

Mr. Westrumb has discovered in them a new principle, a fetid resin of sulphur (*stinkendes schwefelharz.*) To obtain this the sulphureous water must be evaporated in open vessels and the residuum dissolved in alcohol, which takes up this resin and the earthy muriats. By evaporating the alcohol, this substance appears at first as a yellowish fat, which gradually assumes a brown colour, and becomes resinous. By repeated solutions in alcohol and evaporations, it is decomposed into sulphur and a blackish brown resin. It emits a garlic smell, which becomes very strong, and similar to that of assafœtida if water be poured into the alcoholic solution. Its solution acts as an acid.

The resin is soluble in ammonia, and communicates to it a yellow colour. This liquor comports itself like that of Beguin. With lime water a hydrosulphuret is formed. All these solutions act on metallic compounds in the same manner as sulphuretted hydrogen.

As sulphureous mineral waters arise from strata of pitcoal, perhaps the source of this bituminous principle may be traced to pitcoal itself.

Beside these substances, certain vegetable and and animal matters have been occasionally observed in mineral waters. But in most cases these are rather to be considered in the light of accidental mixtures, than of real component parts of the waters in which they occur.

From this synoptical view of the different ingredients contained in mineral waters, it is evident, that these substances occur in two different distinct states, viz. 1. As being suspended in them: and 2. as being dissolved in them chiefly in the form of a salt.

The investigation of mineral waters consists: 1. In the examination of them by the senses. 2. In the examination of them by re-agents. 3. In the analysis properly so called.

The examination by the senses consists in observing the effect of the water as to appearance, smell and taste.

The appearance of the water, the instant in which it is pumped out of the well, as well as after it has stood for some time, affords several indications, from which we are enabled to form a judgment concerning its contents. If the water be turbid at the well, the substances are suspended only, and not dissolved; but if the water be clear and transparent at the well, and some time intervenes before it becomes turbid, the contents are dissolved by means of carbonic acid.

The presence of this gas is likewise indicated by small bubbles, that rise from the bottom of the well, and burst in the air while they are making their escape, though the water at the same time perhaps has not an acid taste. This is the case, according to count Razoumowski, with respect to the tepid spring in Vallais, and the cold vitriolated chalybeate springs at Astracan. But the most evident proof of a spring containing carbonic acid, is the generation of bubbles on the water being shaken, and their bursting with more or less noise, while the air is making its escape.

The sediment deposited by the water in the well, is likewise to be examined; if it be yellow, it indicates the presence of iron; if black, that of iron combined with sulphur; but chalybeate waters being seldom sulphuretted, the latter occurs very rarely. As to the colour of the water itself, there are few instances where this can give any indication of its contents, as there are not many substances that colour it.

The odour of the water serves chiefly to discover the presence of sulphuretted hydrogen in it: such waters as contain this substance have a peculiar fetid smell, somewhat resembling rotten eggs.

The taste of a spring, provided it be perfectly ascertained by repeated trials, may afford some useful indications with respect to the contents. It may be made very sensible by tasting water, in which the various salts that are usually found in such waters are dissolved in various proportions. There is no certain dependance, however, to be placed on this mode of investigation; for in many springs the taste of sulphate of soda is disguised by that of the sea salt united with it. The water too is not only to be tasted at the spring, but after it has stood for some time. This precaution must be particularly observed with respect to such waters as are impregnated with carbonic acid; for the other substances contained in them make no impression on the tongue, till the carbonic acid has made its escape; and it is for the same reason, that these waters must be evaporated in part, and then tasted again.

Though the specific gravity of any water contributes but very little towards determining the contents, still it may not be entirely useless to know the specific weight of the water, the situation of the spring, and the kind of sediment deposited by it.

The examination of the water by means of reagants shows what they contain, but not how much of each principle. In many instances this is as much as the inquiry demands; but it is always of use to direct the proceedings to the proper analysis.

It is absolutely necessary to make the experiment with water just taken up from the spring, and afterwards with such as has been exposed for some hours to the open air; and sometimes a third essay is to be made with a portion of the water that has been boiled and afterwards filtered. If the water contain but a few saline particles, it must be evaporated; as even the most sensible re-agents do not in the least affect it, if the salts, the presence of which is to be discovered by them, are diluted with too great a quantity of water. Now, it may happen, that a water shall be impregnated with a considerable number of saline particles of different kinds, though some of them may present in a very small quantity: for which reason the water must be examined a second time, after having been boiled down to three fourths. For the analysis of mineral waters see Tests.

By reagants we may detect the presence of the different substances commonly found in waters, but as they are generally combined so as to form salts, it is necessary we should know what these combinations are. This is a more difficult task, which Mr. Kirwan teaches us to accomplish by the following methods:

1. To ascertain the presence of the different sulphats.

The sulphats which occur in water are seven; but one of these, namely, *sulphate of copper*, is so uncommon, that it may be excluded altogether. The same remark applies to sulphate of ammonia. It is almost unnecessary to observe, that no sulphate need be looked for, unless both its acid and base have been previously detected in the water.

Sulphate of soda may be detected by the following method: free the water to be examined of all earthy sulphats, by

evaporating it to one half, and adding lime water as long as any precipitate appears. By these means the earths will all be precipitated except lime, and the only remaining earthy sulphate will be sulphate of lime, which will be separated by evaporating the liquid till it becomes concentrated, and then dropping into it a little alcohol, and after filtration adding a little oxalic acid.

With the water thus purified, mix solution of lime. If a precipitate appear, either immediately or on the addition of a little alcohol, it is a proof that sulphate of potash or of soda is present. Which of the two may be determined, by mixing some of the purified water with acetat of barytes. Sulphate of barytes precipitates. Filter and evaporate to dryness. Digest the residum in alcohol. It will dissolve alkaline acetat. Evaporate to dryness, and the dry salt will deliquesce if it be acetat of potash, but effloresce if it be acetat of soda.

Sulphate of lime may be detected, by evaporating the water suspected to contain it, to a few ounces. A precipitate appears, which, if it be a sulphate of lime, is soluble in 500 parts of water; and the solution affords a precipitate with the muriat of barytes, oxalic acid, carbonat of magnesia, and alcohol.

Alum may be detected by mixing carbonat of lime with the water suspected to contain it. If a precipitate appear, it indicates the presence of alum, or at least of sulphate of alumine; provided the water contains no muriat of barytes, or metallic sulphats. The first of these salts is incompatible with alum. The second may be removed by the alkaline prussiats. When a precipitate is produced in water by muriat of lime, carbonat of lime, and muriat of magnesia, we may conclude, that it contains alum or sulphate of alumine.

Sulphate of magnesia may be detected by means of hydrosulphuret of strontian, which occasions an immediate precipitate with this salt, and with no other; provided the water be previously deprived of alum, if any be present, by means of carbonat of lime, and provided also that it contains no uncombined acid.

Sulphate of iron is precipitated from water by alcohol, and then it may be easily recognized by its properties.

2 To ascertain the presence of the different muriats.

The muriats found in waters amount to eight, or to nine, if muriat of iron be included. The most common by far, is muriat of soda.

Muriat of soda and of potash may be detected by the following method: separate the sulphuric acid by alcohol and nitrate of barytes. Decompose the earthy nitrates and muriats, by adding the sulphuric acid. Expel the excess of muriatic, and nitric acids by heat. Separate the sulphates thus formed by alcohol and barytes water. The water thus purified can contain nothing but alkaline nitrats and muriats. If it form a precipitate with acetat of silver, we may conclude, that it contains muriat of soda or of potash. To ascertain which, evaporate the liquid thus precipitated to dryness. Dissolve the acetat in alcohol, and again evaporate to dryness. The salt will deliquesce, if it be acetat of potash; but effloresce, if it be acetat of soda.

Muriat of barytes may be detected by sulphuric acid, as it is the only barytic salt hitherto found in water.

Muriat of lime may be detected by the following method: Free the water from sulphate of lime and other sulphats, by evaporating it to a few ounces, mixing it with alcohol, and adding last of all nitrate of barytes, as long as any preipitate appears. Filter the water; evaporate to dryness; treat the dry mass with alcohol; evaporate the alcohol to dryness; and dissolve the residum in water. If this solution give a precipitate with acetat of silver and oxalic acid, it may contain muriat of lime. It must contain it in that case, if, after being treated with carbonat of lime, it give no precipitate with ammonia. If the liquid in the receiver give a precipitate with nitrate of silver, muriat of lime existed in the water.

Muriat of magnesia may be detected by separating all the sulphuric acid by means of nitrate of barytes. Filter, evaporate to dryness, and treat the dry mass with alcohol. Evaporate the alcoholic solution to dryness, and dissolve the residuum in water. The muriat of magnesia, if the water contained any, will be found in this solution. Let us suppose that, by the tests formerly described, the presence of muriatic acid and of magnesia in this solution has been ascertained. In that case, if carbonate of lime afford no precipitate, and if sulphuric acid and evaporation, together with the addition of a little alcohol, occasion no precipitate, the solution contains only muriat of magnesia. If these tests give precipitates, we must separate the lime which is present by sulphuric acid and alcohol, and distil off the acid with which it was combined. Then the magnesia is to be separated by the oxalic acid and alcohol, and the acid with which it was united is to be distilled off. If the liquid in the retort give a pre-

cipitate with nitrate of silver, the water contains muriat of magnesia.

Muriat of alumine may be discovered by saturating the water, if it contain an excess of alkali, with nitric acid, and by separating the sulphuric acid by means of nitrate of barytes. If the liquid thus purified give a precipitate with carbonate of lime, it contains muriat of alumine. The muriat of iron, *manganese*, if any be present, is also decomposed, and the iron precipitated by this salt. The precipitate may be dissolved in muriatic acid, and the alumine, iron and manganese, if they be present, may be separated by the rules laid down below.

3. To ascertain the presence of the different nitrates. The nitrates but seldom occur in waters; but when they do, they may be detected by the following results:

Alkaline nitrates may be detected by freeing the water examined from sulphuric acid by means of acetat of barytes, and from muriatic acid by acetat of silver. Evaporate the filtered liquid, and treat the dry mass with alcohol; what the alcohol leaves can consist only of the alkaline nitrates and acetat of lime. Dissolve it in water. If carbonate of magnesia occasion a precipitate, lime is present. Separate the lime by means of carbonate of magnesia. Filter and evaporate to dryness, and treat the dried mass with alcohol The alcohol now leaves only the alkaline nitrates, which may be easily recognised, and distinguished by their respective properties.

Nitrate of lime. To detect this salt, concentrate the water, and mix it with alcohol to separate the sulphates. Filter and distil off the alcohol; then separate the muriatic acid by acetat of silver. Filter, evaporate to dryness, and dissolve the residuum in alcohol. Evaporate to dryness, and dissolve the dry mass in water. If this last solution indicate the presence of lime by the usual tests, the water contained nitrate of lime.

To detect nitrate of magnesia, the water is to be freed from sulphate and muriats exactly as described in the last paragraph. The liquid thus purified is to be evaporated to dryness, and the residuum treated with alcohol. The alcoholic solution is to be evaporated to dryness, and the dry mass dissolved in water. To this solution potash is to be added, as long as any precipitate appears. The solution filtered, and again evaporated to dryness, is to be treated with alcohol If it leave a residuum consisting of nitre (the only residuum which it can leave) the water contained nitrate of magnesia.

Such are the methods, by which the presence of the different saline contents of waters may be ascertained. The labour of analysis may be considerably shortened, by observing that the following salts are incompatible with each other, and cannot exist together in water, except in very minute proportion.

Salts.	*Incompatible with*
Fixed alkaline sulphats	Nitrates of lime and magnesia. Muriats of lime and magnesia.
Sulphate of lime	Alkalis, Carbonat of magnesia, Muriat of barytes.
Alum	Alkalis, Muriat of barytes, Nitrate, muriat, carbonat of lime, Carbonat of magnesia.
Sulphate of magnesia	Alkalis, Muriat of barytes, Nitrate & muriat of lime.
Sulphate of iron	Alkalis, Muriat of barytes, Earthy Carbonats.
Muriat of barytes	Sulphates, Alkaline carbonats, Earthy Carbonats
Muriat of lime	Sulphates, except of lime, Alkaline carbonats, Earthy carbonats
Muriat of magnesia	Alkaline carbonats Alkaline sulphates
Nitrate of lime	Alkaline carbonats, Carbonat of magnesia & alumine, Sulphates, except of lime.

Beside the substances above described there is sometimes found in water a quantity of bitumen combined with alkali, and in the state of soap. In such waters, acids occasion a coagulation; and the coagulum collected on a filter discovers its bituminous nature by its combustibility.

Water also sometimes contains extractive matter; the presence of which may be detected by means of nitrate of silver. The water suspected to contain it must be freed from sulphuric and nitric acid by means of nitrate of lead: after this, if it give a brown precipitate with nitrate of silver, we may conclude, that extractive matter is present.

But it is not sufficient to know, that a mineral water contains certain ingredients it is necessary to ascertain the proportions of these, and thus we arrive at their complete analysis

The proportion of all the saline ingredients, held in solution by any water, may

be in some measure estimated from its specific gravity. The lighter a water is the less saline matter does it contain; and on the other hand, the heavier it is, the greater is the proportion of saline contents. Mr. Kirwan has pointed out a very ingenious method of estimating the saline contents of a mineral water, the specific gravity of which is known; so that the error will not exceed one or two parts in the hundred. The method is this: Subtract the specific gravity of pure water from the specific gravity of the mineral water examined (both expressed in whole numbers) and multiply the remainder by 1·4. The product is the saline contents in a quantity of the water denoted by the number employed to indicate the specific gravity of distilled water. Thus let the water be of the specific gravity 1·079, or in the whole numbers 1079. Then the syecific gravity of distilled water will be 1000. And $\overline{1079-1000} \times 1{\cdot}4 = 110{\cdot}6$ the saline contents in 1000 parts of the water in question; and consequently 11·06 in 100 parts of the same water. This formula will often be of considerable use, as it serves as a kind of standard, to which we may compare our analysis. The saline contents indicated by it, are supposed to be freed from their water of crystallization, in which state they ought only to be considered, as Mr. Kirwan has very properly observed, when we speak of the saline contents of a mineral water.

Having by this formula ascertained pretty nearly the proportion of saline contents in the water examined, and having by the test just described, determined the particular substances that exist in it, we may proceed to ascertain the proportion of each of these ingredients.

1. The different aerial fluids ought to be first separated and estimated For this purpose a retort should be filled two thirds with the water, and connected with a jar full of mercury, standing over a mercurial trough Let the water be made to boil for a quarter of an hour. The aerial fluids will pass over into the jar. When the apparatus is cool, the quantity of air expelled from the water may be determined either by bringing the mercury within, and without the jar to a level; or if this cannot be done, by reducing the air to the proper density by calculation. The air of the retort ought to be carefully subtracted, and the jar should be divided into cubic inches and tenths.

The only gaseous bodies contained in water, are common air, oxygen gas, nitrogen gas, carbonic acid, sulphuretted hydrogen gas, and sulphurous acid. The last two never exist in water together. The presence of either of them must be ascertained previously by the application of the proper tests. If sulphuretted hydrogen gas be present, it will be mixed with the air contained in the glass jar, and must be separated before this air be examined. For this purpose the jar must be removed into a tub of warm water, and nitric acid introduced, which will absorb the sulphuretted hydrogen. The residuum is then to be again put into a mercurial jar and examined.

If the water contain sulphurous acid, this previous step is not necessary. Introduce into the air a solution of pure potash and agitate the whole gently. The carbonic acid and sulphurous acid gas will be absorbed, and leave the other gasses. The bulk of this residuum subtracted from the bulk of the whole, will give the bulk of the carbonic acid and sulphurous acid absorbed

Evaporate the potash slowly, almost to dryness, and leave it exposed to the atmosphere. Sulphate of potash will be formed, which may be separated by dissolving the carbonat of potash by means of diluted muriatic acid, and filtering the solution. 100 grains of sulphate of potash indicate 30 grains of sulphurous acid, or 42·72 cubic inches of that acid in the state of gas. The bulk of sulphurous acid gas ascertained by this method, subtracted from the bulk of the gas absorbed by the potash, gives the bulk of the carbonic acid gas. Now 100 cubic inches of carbonic acid, at the temperature of 60° and barometer 30 inches, weigh 43·393 grains. Hence it is easy to ascertain its weight.

The gas remaining may be examined by the common eudiometrical processes.

When a water contains sulphuretted hydrogen gas, the bulk of this gas is to be ascertained in the following manner: Fill three fourths of a jar with the water to be examined, and invert it in a water trough, and introduce a little nitrous gas. This gas, mixing with the air in the upper part of the jar, will form nitrous acid, which will render the water turbid, by decomposing the sulphuretted hydrogen and precipitating sulphur. Continue to add nitrous gas at intervals as long as red fumes appear, then turn up the jar and blow out the air. If the hepatic smell continue, repeat this process. The sulphur precipitated, indicates the proportion of hepatic gas in the water; one grain of sulphur indicating the presence of 3·33 cubic inches of this gas.

2. After having estimated the gaseous bodies, the next step is to ascertain the

proportion of the earthy carbonats. For this purpose it is necessary to deprive the water of its sulphuretted hydrogen, if it contain any. This may be done, either by exposing it to the air for a considerable time, or treating it with litharge. A sufficient quantity of the water, thus purified if necessary, is to be boiled for a quarter of an hour, and filtered when cool. The earthy carbonats remain on the filter.

The precipitate thus obtained may be carbonat of lime, of magnesia, of iron, of alumine, or even sulphate of lime. Let us suppose all of these substances to be present together. Treat the mixture with diluted muriatic acid, which will dissolve the whole except the alumine and sulphate of lime. Dry this residuum in a red heat, and note the weight. Then boil it in carbonat of soda; saturate the soda with muriatic acid, and boil the mixture for half an hour. Carbonat of lime and alumine precipitate. Dry this precipitate and treat it with acetic acid. The lime will be dissolved, and the alumine will remain. Dry it and weigh it. Its weight subtracted from the original weight gives the proportion of sulphate of lime.

The muriatic solution contains lime, magnesia and iron. Add ammonia as long as a reddish precipitate appears. The iron and part of the magnesia are thus separated. Dry the precipitate, and expose it to the air for some time in a heat of 200°; then treat it with the acetic acid to dissolve the magnesia, which solution is to be added to the muriatic solution. The iron is to be re-dissolved in muriatic acid, precipitated by an alkaline carbonat, dried and weighed.

Add sulphuric acid to the muriatic solution as long as any precipitate appears; then heat the solution and concentrate. Heat the sulphate of lime thus obtained to redness, and weigh it. 100 grains of it are equivalent to 70 of carbonat lime dried. Precipitate the magnesia by means of carbonat of soda Dry it and weigh it. But as part remains in solution, evaporate to dryness, and wash the residuum with a sufficient quantity of distilled water, to dissolve the muriat of soda and sulphate of lime, if any be still present. What remains behind is carbonat of magnesia. Weigh it, and add its weight to the former. The sulphate of lime, if any, must also be separated and weighed.

3. We have next to ascertain the proportion of mineral acids or alkalis, if any be present uncombined. The acids which may be present, omitting the gaseous, are the sulphuric, muriatic and boracic.

The proportion of sulphuric acid is easily determined. Saturate it with barytes water, and ignite the precipitate. 100 grains of sulphate of barytes thus formed indicate 23·5 of real sulphuric acid.

Saturate the muriatic acid with barytes water, and then precipitate the barytes by sulphuric acid. One hundred parts of the ignited precipitate are equivalent to 21 grains of real muriatic acid.

Precipitate the boracic acid by means of acetat of lead. Decompose the borat of lead by boiling it in sulphuric acid. Evaporate to dryness. Dissolve the boracic acid in alcohol, and evaporate the solution; the acid left behind may be weighed.

To estimate the proportion of alkaline carbonat present in a water containing it, saturate it with sulphuric acid, and note the weight of real acid necessary. Now 100 grains of real sulphuric acid saturate 121·48 potash, 73·32 soda.

4. The alkaline sulphate may be estimated by precipitating their acid by means of nitrate of barytes, having previously freed the water from all other sulphats; for 170 grains of ignited sulphate of barytes indicate 100 grains of dried sulphate of soda; while 136·36 grains of barytes indicate 100 of dry sulphate of potash.

Sulphate of lime is easily estimated by evaporating the liquid containing it, to a few ounces (having previously saturated the earthy carbonats with nitric acid,) and precipitating the sulphate of lime by means of weak alcohol. It may then be dried and weighed.

The quantity of alum may be estimated by precipitating the alumine by carbonat of lime or of magnesia (if no lime be present in the liquid.) Twelve grains of the alumine heated to incandescence indicate 100 of crystallized alum, or 49 of dried salt.

Sulphate of magnesia may be estimated, provided no other sulphate be present, by precipitating the acid by means of a barytic salt, as 100 parts of ignited sulphate of barytes indicate 52·11 of sulphate of magnesia. If sulphate of lime, and no other sulphate, accompany it, this may be decomposed, and the lime precipitated by carbonat of magnesia. The weight of the lime thus obtained enables us to ascertain the quantity of sulphate of lime contained in the water. The whole of the sulphuric acid is then to be precipitated by barytes. This gives the quantity of sulphuric acid; and subtracting the portion which belongs to the sulphate of lime, there remains that which was

combined with the magnesia, from which the sulphate of magnesia may be easily estimated.

If sulphate of soda be present, no earthy nitrate or muriat can exist. Therefore, if no other earthy sulphate be present, the magnesia may be precipitated by soda, dried and weighed; 36·68 grains of which indicate 100 grains of dried sulphate of magnesia. The same process succeeds when sulphate of lime accompanies these two sulphates; only in this case the precipitate, which consists both of lime and magnesia, is to be dissolved in sulphuric acid, evaporated to dryness, and treated with twice its weight of cold water, which dissolves the sulphate of magnesia, and leaves the other salt Let the sulphate of magnesia be evaporated to dryness, exposed to a heat of 400° and weighed. The same process succeeds, if alum be present instead of sulphate of lime. The precipitate in this case, previously dried, is to be treated with acetic acid, which dissolves the magnesia and leaves the alumine. The magnesia may be again precipitated, dried and weighed. If sulphate of iron be present, it may be separated by exposing the water to the air for some days, and mixing with it a portion of alumine. Both the oxide of iron and the sulphate of alumine, thus formed, precipitate in the state of an insoluble powder. The sulphate of magnesia may then be estimated by the rules above given.

Sulphate of iron may be estimated by precipitating the iron by means of prussic alkali, having previously determined the weight of the precipitate produced by the prussiat in a solution of a given weight of sulphate of iron in water. If muriat of iron be also present, which is a very rare case, it may be separated by evaporating the water to dryness, and treating the residuum with alcohol, which dissolves the muriat, and leaves the sulphate.

5. If muriat of potash or of soda, without any other salt exist in water, we have only to decompose them by nitrate of silver, and dry the precipitate; for 217·65 of muriat of silver indicate 100 of muriat of potash; and 235 of muriat of silver indicate 100 of common salt.

The same process is to be followed, if the alkaline carbonats be present; only these carbonats must be previously saturated with sulphuric acid; and we must precipitate the muriatic acid by means of sulphate of silver, instead of nitrate. The presence of sulphate of soda does not injure the success of this process.

If muriat of ammonia accompany either of the fixed alkaline sulphats, without the presence of any other salt, decompose the sal ammoniac by barytes water, expel the ammonia by boiling, precipitate the barytes by diluted sulphuric acid, and saturate the muriatic acid with soda. The sulphate of barytes thus precipitated, indicates the quantity of muriat of ammonia; 100 grains of sulphate indicating 49·09 grains of this salt. If any sulphats be present in the solution, they ought to be previously separated.

If common salt be accompanied by muriat of lime, muriat of magnesia, muriat of alumine, or muriat of iron, or by all these together, without any other salt, the earths may be precipitated by barytes water, and re-dissolved in muriatic acid. They are then to be separated from each other by the rules formerly laid down, and their weight being determined, indicates the quantity of every particular earthy muriat contained in the water. For 50 grains of lime indicate 100 of dried muriat of lime; 30 grains of magnesia indicate 100 of the muriat of that earth; and 21·8 grains of alumine indicate 100 of the muriat of alumine. The barytes is to be separated from the solution by sulphuric acid, and the muriatic acid expelled by heat, or saturated with soda; the common salt may then be ascertained by evaporation, subtracting in the last case the proportion of common salt, indicated by the known quantity of muriatic acid, from which the earths had been separated.

When sulphats and muriats exist together, they ought to be separated either by precipitating the sulphats by means of alcohol, or by evaporating the whole to dryness, and dissolving the earthy muriats in alcohol. The salts thus separated may be estimated by the rules already laid down.

When alkaline and earthy muriats, and sulphate of lime occur together, the last is to be decomposed by means of muriat of barytes. The precipitate ascertains the weight of sulphate of lime contained in the water. The estimation is then to be conducted as when nothing but muriats are present; only from the muriat of lime, that proportion of muriat must be deducted, which is known to have been formed by the addition of the muriat of barytes.

When muriats of soda, magnesia and alumine, are present together with sulphats of lime and magnesia, the water to be examined ought to be divided into two equal portions. To the one portion add carbonat of magnesia, till the whole of the lime and alumine is precipitated. Ascer-

tain the quantity of lime, which gives the proportion of sulphate of lime. Precipitate the sulphuric acid, by muriate of barytes. This gives the quantity contained in the sulphate of magnesia, and sulphate of lime; subtracting this last portion, we have the quantity of sulphate of magnesia..

From the second portion of water, precipitate all the magnesia and alumine by means of lime-water. The weight of these earths, enables us to ascertain the weight of muriate of magnesia and of alumine contained in the water, subtracting that part of the magnesia, which existed in the state of sulphate, as indicated by the examination of the first portion of water. After this estimation, precipitate the sulphuric acid by barytes water, and the lime by carbonic acid. The liquid evaporated to dryness, leaves the common salt.

6. It now only remains to explain the method of ascertaining the proportion of the nitrates which may exist in waters.

When nitre accompanies sulphates and muriates without any other nitrates, the sulphates are to be decomposed by acetate of barytes, and the muriates by acetate of silver. The water, after filtration, is to be evaporated to dryness, and the residuum treated with alcohol, which dissolves the acetates, and leaves the nitre, the quantity of which may be easily calculated. If an alkali be present, it ought to be previously saturated with sulphuric or muriatic acid.

If nitre, common salt, nitrate of lime, and muriate of lime or magnesia, be present together, the water ought to be evaporated to dryness, and the dry mass treated with alcohol, which takes up the earthy salts. From the residuum re-dissolved in water, the nitre may be separated, and calculated as in the last case. The alcoholic solution is to be evaporated to dryness, and the residuum re-dissolved in water. Let us suppose it to contain muriate of magnesia, nitrate of lime, and muriate of lime. Precipitate the muriatic acid, by nitrate of silver, which gives the proportion of muriate of magnesia and of lime. Separate the magnesia by means of carbonate of lime, and note its quantity. This gives the quantity of muriate of magnesia; and substracting the muriatic acid contained in that salt, from the whole acid, indicated by the precipitate of silver, we have the proportion of muriate of lime.

Lastly, saturate the lime added to precipitate the magnesia, with nitric acid. Then precipitate the whole of the lime, by sulphuric acid; and substracting from the whole of the sulphate thus formed, that portion formed by the carbonate of lime added, and by the lime contained in the muriate, the residuum gives us the lime contained in the original nitrate; and 35 grains of lime, form 100 of dry nitrate of lime.

WATER, MINERAL, ARTIFICIAL. Mineral waters, *exactly* in imitation of the natural, are not kept in the shops of the apothecaries, but if the exact ingredients in proper proportions were used, the imitation would be precise. Hence it is, that the water generally sold, as the Pyrmont, Seltzer, &c. are variable in their contents. We shall here observe, that *all* the waters, called mineral, as sold in our city, and we are informed, in Europe, (except otherwise ordered) contain carbonic acid gas, or fixed air, either alone or combined with a base, or mixed with certain saline substances. We shall first enumerate the contents of those mineral waters, which are mostly imitated, and treat generally of the artificial.

Aix-la-Chapelle, see the latter part of this article.

Bath of Somersetshire, England. As it comes from the pump, it contains a quantity of air, which rises through the water in the bath, in large clusters of bubbles. This is found to consist of equal parts of carbonic acid gas, and hydrogen gas, mixed with a little atmospheric air, amounting in the whole to 16 cubic inches in the gallon.

Its solid contents are, in the gallon, sulphate of lime 31.5 grs., carbonate of lime 7.25 grs., sulphate of soda 26 grs., muriate of soda 52 grs., silex 15.25, oxyd of iron 0.25.

Bordscheit, or *Borset*, about a mile and a half from Aix-la-Chapelle, Germany.

One of the springs of Borset resembles those of Aix, in all its constituent parts, but the impregnation with sulphur is much weaker. It deposits however, some sulphur in its course, through any confined channel on its upper part, but not sufficient to be worth collecting. It is pretty strongly alkaline. Its temperature is 132° Fahr. which is nearly as high as the hottest bath at Aix.

The other hot spring differs considerably from the former, in containing no sulphur in any form; it therefore has no smell, nor does it blacken the solutions of silver or lead. It is, however equally alkaline, and the heat is as high as 152° Fahr. and therefore much exceeds the hottest of the Aken waters. In this spring there is a large quantity of earth suspended, which is deposited as the water cools, and forms hard incrustations, to a consi-

derable thickness round every substance, that may lie in its way, and will serve as a nucleus.

Brighton. The chalybeate spring near Brighton, commonly called the Wick, has long been noticed as a ferruginous water.

A gallon of the water, according to Dr. Marcet's analysis, contains sulphate of iron 11.2 grs., sulphate of lime 32.72 grs., muriate of soda 12.24 grs, muriate of magnesia 6 grs., siliceous earth 1.12 grs., all dried at 160° Fahr. carbonic acid gas about 18 cubic inches, or one-thirteenth part of its volume.

Bristol, in Somersetshire.

The springs are known by the name of the *Hot Wells.*

The water at its origin is warm, clear, pellucid and sparkling; and if suffered to stand in a glass, covers its inside with small air bubbles. It has no smell, and is soft and agreeable to the taste. It raises the thermometer to about seventy or eighty degrees. It contains in the gallon 12.75 grs. of chalk, 7.25 of muriate of magnesia, 4 of sea salt, (sulphate of soda) 11.25, sulphate of lime 11.75, carbonate of lime 13.5, and 30 cubic inches of carbonic acid gas.

Caroline Baths, at Carlsbad in Bohemia, Germany.

The waters of this place are hot. The highest temperature is 165° Fahr. the lowest 114°.

According to Klaproth the *Sprudel* contains in 100 cubic inches, carbonate of soda 39 grs, sulphate of soda 70.5, muriate of soda 34.6, chalk 12 grs., silex 2.5 grs., iron 0.125 grs., carbonic acid gas 32 cubic inches.

The *Neubrunnen*, carbonate of soda 38.5 grains, sulphate of soda 66.75, muriate of soda 32.5, chalk 12.4, silex 2.5 iron 0.125 grs., carbonic acid gas 50 cubic inches.

The *Schlossbrunnen*, carbonate of soda 37.5 grains, sulphate of soda 66.5 muriate of soda 33, chalk 12.75, silex 2.125, iron 0.0625, carbonic acid gas fifty-three cubic inches.

Cheltenham, in Gloucestershire, six miles from Gloucester, England.

The gallon contains eight drachms of a purging salt, partly sulphate of soda, partly sulphate of magnesia; twenty-five grains of magnesia, part of which is united with muriatic, part with carbonic acid; and nearly five grains of oxide of iron. It also yields 30.368 cubic inches of carbonic acid gas, and 15.184 of a mixture consisting chiefly of nitrogen gas, with a little sulphuretted hydrogen.

Epsom, in Surry, about sixteen miles from London.

This water has never been analysed with much nicety. Its solid contents have been made to amount to an ounce and a half in the gallon, but according to Dr. Lucas, they are only 320 grs. Of these two-thirds or more are sulphate of magnesia, the remainder probably muriate of lime and magnesia, with sulphate and carbonate of lime.

Harrowgate, near Knaresborough, Yorkshire, England.

There are four springs at this place, but the waters of all of them are nearly alike, except in the quantity of the saline matter they contain.

Of the three old springs, the highest gave three ounces of solid matter to the gallon; the lowest an ounce and a half; and the middle one, only half an ounce. Of the last one hundred and forty grains were earth.

Of the upper, which alone is used internally, the contents are muriate of soda 615.6 grs., muriate of lime 13, muriate of magnesia 91, carbonate of lime 18.5 carbonate of magnesia 5.5 sulphate of magnesia 10.5 carbonic acid gas 8 cubic inches, nitrogen gas 7, sulphuretted hydrogen 19.

The water as it springs up is clear and sparkling, and throws up a quantity of air bubbles.

Pyrmont, in Westphalia, Germany.

This is a very brisk chalybeate, abounding in carbonic acid; and when taken up from the fountain, sparkles like the briskest Champaign wine. It has a fine, pleasant, vinous taste, and a somewhat sulphureous smell. It is perfectly clear, and bears carriage better than the Spa water.

A gallon of it contains 46 grains of carbonate of lime, 15.6 of carbonate of magnesia, 30 of sulphate of magnesia, 10 of sea salt, 2.6 of oxyd of iron; and upwards of 200 cubic inches of carbonic acid gas.

Seltzer, in Germany.

The water is remarkably clear and light, and in pouring it from one vessel to another, plenty of air bubbles arise.

It has, at first, somewhat of a brisk, sub-acid pungent taste, but leaves behind a lixivial one.

It contains 14 grains of carbonate of lime, 20½ of carbonate of magnesia, 141.6 of carbonate of soda, and 92 of muriate of soda, in the gallon. From this quantity of the water 128 ounce measures of carbonic acid gas were obtained.

Seydschutz, in Germany.

It is situate near to that of Sedlitz, and

is of the same purgative nature, but somewhat stronger. The gallon contains of sulphate of magnesia 1620 grs., muriate of magnesia 42 grs., sulphate of soda 33 grs., sulphate of lime 33 grs., carbonate of magnesia 30 grs., carbonate of lime 9 grs., and twenty-seven cubic inches of carbonic acid gas.

Tunbridge. This water contains in a gallon, 1 grain of oxyd of iron, muriate of soda 0.5, muriate of magnesia 2.25, sulphate of lime 1.25, of carbonic acid gas 10 6 cubic inches, azotic gas 4, atmospherical air 1.4.

Some of these waters, and we believe all, in Europe, are made artificially. Of the mineral waters of the United States, though they are generally chalybeate, none except the Ballstown are artificially made.

The waters of Saratoga, Bath, Yellow Spring, York, Colestown and others of an inferior note, though resorted to in the summer months, and found benefical to the invalid, are not prepared artificially as before observed. We shall therefore enumerate the contents of the latter.

The Saratoga water, according to Dr. Seaman, p. 51, contains carbonic acid, carbonate of iron, super-carbonate of lime, muriatic salt, carbonated alkali, carbonated magnesia, and a sulphureous impregnation, and ten pounds of this water consists of carbonic acid gas, or fixed air 200 cubic inches, carbonate of soda 2.6 grs., muriate of soda, 1.73 grs., super carbonate of lime 1.90 grs., and carbonate of lime 8½ grs.

The Ballstown water, according to the same author, p. 78, contains, carbonic acid, muriate of soda, carbonate of lime, carbonare of soda, carbonate of iron, and carbonate of magnesia. The imitation of these waters was made by Dr. Seaman, in the following manner.

To a gallon of simple water in Nooth's apparatus, I added some pieces of marble, (carbonate of lime) 138.4 grs. common salt, and 20.8 of carbonated soda; that quantity being just the proportion obtained from the mineral water. I also suspended in it some rust of iron, tied up in a linen rag. I then caused the air that was discharged from powdered limestone, by a diluted vitriolic acid, to pass through the water above-mentioned, till it appeared to be fully saturated. To this water was added some coarsely powdered sulphur, which after standing awhile, was decanted off.

This liquor was now acknowledged by several persons, who had drank of the Saratoga waters, perfectly to resemble them in taste.

Most of the re-agents used on the natural waters, were repeated on these, and with like effects. Here then is a clear proof of the success of the analysis; for synthesis, or the re-composition of a substance, with similar ingredients to what were obtained from it, is the surest evidence of the correctness of an analysis.

Notwithstanding I have not had an opportunity of trying the effects of this water in many diseases, yet it being composed of the same ingredients as the natural waters, leaves no doubt but that it must possess the same medicinal virtues.

As mineral waters generally contain more or less carbonic acid, and as it is always preferred, when combined with water as a beverage; it is obvious that the manufacturers of these waters often super-saturate the water, with the acid gas. This is done by pressure. The means usually employed, consists in disengaging the gas from chalk, by sulphuric acid or oil of vitriol, receiving it in a suitable vessel, and literally pumping and forcing it, by means of a forcing pump, into a turned copper vessel, previously filled with water, or the solution intended for saturation.

Soda water, is nothing more than four or more grains of soda, contained in a pint or more of water, and saturated with carbonic acid; or by adding a solution of soda, to the aerated water.

Fourcroy, in his General System of Chemical Knowledge, has given the following observations, on the artificial fabrication of mineral waters.

A chemical analysis has long been considered as well executed, when by the aid of synthesis, we can re-compose the matter analized. This truth is applicable to mineral waters, though the synthesis of these, is to be classed among the number of things, that have been discovered within a few years. In fact, we should not depend on the accuracy of an analysis of a water, till we have made an exact imitation of it, by dissolving in the pure fluid, the same principles as we had discovered, and in the same proportions, so that this imitation shall exhibit the same appearances on every trial, and with every reagent, as the natural water.

Since the discoveries of the carbonic acid, and the great variety of saline substances, we have succeeded so well in making accurate analyses of mineral waters, and consequently in re-composing them, that it has given birth to a new art,

of no small importance to mankind, being employed as a remedy in a considerable number of diseases. For this purpose the first thing to be done, is to choose very pure spring or river water, which contains little or no foreign matter : in this, carbonic acid is to be dissolved, if for an acidulous water, and then the salts which analysis has shown the water, we would imitate to contain. If it be a chalybeate water we would fabricate, iron is to be added.

When we would prepare sulphureous waters, we saturate water well boiled and deprived of its air, with sulphuretted hydrogen gas, disengaged from alkaline sulphuret, or sulphuret of iron, on which, previously reduced to powder, is to be poured sulphuric or muriatic acid diluted with water. When this water is so saturated by means of gentle agitation, the salts or fixed matters we know to be contained in it are to be introduced. In this imitation we do not employ the inert substances, as the carbonate, and sulphate of lime, which are found in the natural water we would imitate; we admit only the active sapid salts, which are taken in a pure and crystallized state. We may even employ them in greater quantity, than the natural water contains, and thus prepare waters of greater strength, and more penetrating, than those we would imitate.

Bergman has given the means of thus imitating the waters of Seidschutz, Seltzer, Spa, Pyrmont, St. Charles in Bohemia, and Aix-la-Chapelle. The following are the principles, which, conformably to his analysis, he proposed to be dissolved, to imitate each of these mineral waters, most of which in fact, are in high repute. In this table we shall first give the quantity of the principles in grains, proportioned thus by Bergman, to a quantity of water also estimated in grains, and then their proportions in decimal fractions, or in thousandth parts of the water containing them.

SEIDSCHUTZ WATER.

Weight	=	17991 $\frac{17}{32}$ grains .	= 1000
Specific gravity . .	=	1.0060	
Pure air	=	$\frac{43}{108}$ cubic inches .	= 0,011
Carbonic acid . . .	=	$\frac{45}{103}$ cubic inches .	= 0,015
Carbonate of lime . .	=	1 $\frac{19}{21}$ grains . .	= 0,106
Sulphate of lime . .	=	5 $\frac{5}{52}$ grains . .	= 0,294
Carbonate of magnesia .	=	10 $\frac{3}{8}$ grains . .	= 0,577
Sulphate of magnesia .	=	363 $\frac{13}{16}$ grains .	= 20,812
Muriate of magnesia .	=	7 $\frac{5}{14}$ grains . .	= 0,512

SELTZER WATER.

Weight	=	17932 $\frac{17}{32}$ grains .	= 1000
Specific gravity . .	=	1,0027	
Pure air	=	$\frac{43}{108}$ cubic inches .	= 0,011
Carbonic acid . . .	=	24 cubic inches .	= 0,910
Carbonate of lime . .	=	7 $\frac{3}{32}$ grains . .	= 0,396
Carbonate of magnesia .	=	12 $\frac{1}{2}$ grains . .	= 0,697
Carbonate of soda . .	=	10 $\frac{5}{32}$ grains . .	= 0,566
Muriate of soda . .	=	46 $\frac{11}{32}$ grains . .	= 2,684

SPA WATER.

Weight	=	17902 $\frac{1}{8}$ grains .	= 1000
Specific gravity . .	=	1,0010	
Carbonic acid . . .	=	18 cubic inches .	= 0,684
Carbonate of lime . .	=	3 $\frac{19}{32}$ grains . .	= 0,201
Carbonate of magnesia .	=	8 $\frac{7}{15}$ grains . .	= 0.479
Carbonate of soda . .	=	3 $\frac{19}{32}$ grains . .	= 0,201

Carbonate of iron . .	=	$1\frac{3}{8}$ grains . .	=	0,077
Muriate of soda . .	=	$\frac{8}{19}$ grains . .	=	0,023

PYRMONT WATER.

Weight	=	$17927\frac{2}{13}$ grains .	=	1000
Specific gravity . .	=	1,0024		
Carbonic acid . . .	=	$37\frac{2}{3}$ cubic inch .	=	1,429
Carbonate of lime . .	=	$8\frac{7}{15}$ grains . .	=	0,473
Carbonate of magnesia .	=	$19\frac{1}{20}$ grains . .	=	1,063
Carbonate of iron . .	=	$1\frac{3}{100}$ grains . .	=	0,079
Sulphate of lime . .	=	$16\frac{3}{10}$ grains . .	=	0,907
Sulphate of magnesia .	=	$10\frac{3}{8}$ grains . .	=	0,579
Muriate of soda . .	=	$2\frac{31}{32}$ grains . .	=	0,165

WATER OF ST. CHARLES IN BOHEMIA.

				Heat $58\frac{2}{5}$
Weight	=	17900 grains . .	=	1000
Specific gravity . .	=			
Sulphuretted hydrogen gas	=	24 cubic inches .	=	0,442
Carbonate of lime . .	=	$10\frac{5}{32}$ grains . .	=	0,568
Carbonate of soda . .	=	$28\frac{3}{8}$ grains . .	=	1,585
Sulphur	=	$3\frac{7}{19}$ grains . .	=	0,188
Sulphate of soda . .	=	$100\frac{1}{8}$ grains . .	=	5,593

WATER OF AIX-LA-CHAPELLE.

				Heat $49\frac{2}{5}$
Weight	=	17897 grains . .	=	1000
Specific gravity . .	=			
Sulphuretted hydrogen gas	=	24 cubic inches .	=	0,443
Carbonate of lime . .	=	$11\frac{13}{32}$ grains . .	=	0,638
Carbonate of soda . .	=	$29\frac{5}{8}$ grains . .	=	1,655
Sulphur	=	$3\frac{7}{19}$ grains . .	=	0,188
Muriate of soda . .	=	$12\frac{9}{32}$ grains . .	=	0,692

Lately, art has gained much in the imitation of mineral waters, particularly of those which are impregnated with elastic fluids, and are indebted to these for their virtues. By the help of machines, exerting great pressure, water is made to imbibe four, five, or even six times its bulk, of carbonic acid, so that art thus impregnates it, with more than nature does. The same is effected with sulphuretted hydrogen gas, and even with oxygen gas; and there is reason to presume, that by this process will be formed a new materia medica, derived from the properties of elastic fluids.

The saturation of water with carbonic acid gas, may be accomplished in the small way, by means of Priestley's or Nooth's apparatus; but in the large way, no other mode is used than the pressure of a forcing pump.

We shall not attempt a description of the apparatus minutely, as it would be of little or no advantage, and require the assistance of several plates; but generally observe, that the aerated waters, are made by impregnating water with fixed air, and in order to saturate the fluid, to make it absorb several times its bulk of air, the means employed is a forcing-pump, which is worked by different contrivances, as a wheel, lever, &c. The quantity of gas to be produced, is to be calculated from the quantity of chalk, marble, or lime-stone employed, always allowing about one part of oil of vitriol,

to two parts of the chalk, &c. previously diluting it with water. The gas will be instantly extricated, and is then to be conveyed by a pipe into a vessel, from which it is conducted, and at the same time forced into a copper vessel, tinned inside and containing water, by a forcing pump. When the vessel holding the aerated water is removed, and the necessary pipes affixed; by turning a stop-cock the water will extricate itself with considerable power, producing a sparkling appearance. Although the discharging pipe may be several feet perpendicular, and the vessel itself not holding more than 16 or 20 gallons, yet the effect is such, that nearly all the water will ascend the pipe, owing to the great pressure of the gas, and the exertion it makes to obtain an equilibrium. These remarks, therefore, on the manufacture generally of mineral waters, however imperfect they may appear, and however confined, may at least be productive of some advantage, and especially lead to more correct formulæ than heretofore adopted, by some of the fabricators of these waters. We may however state, that so far from following any given rule, some of the manufacturers merely add the particular substance, (as soda in solution) to water saturated with the gas, without observing an uniformity, and so frequently, of other waters, which they would imitate.

WATER COLOURS. See Colour Making.

WATER-FILTERING-MACHINES. See Filtration.

WATER, *preservation and purification of.*

We shall here give some general observations, on the preservation of water, as it is a subject of importance, especially at sea on long voyages.

It has been recommended to add a small quantity of lime, to every cask of water. Dr. Butler advises four ounces of fine clear pearl-ash, to be dissolved in 100 gallons of fresh water, and the cask to be closed in the usual manner.

Dr. Butler relates, that he put one oz. of such alkali, into a cask containing 25 gallons of Thames-water, and suffered it to stand for upwards of a year and a half, opening it once in four months; when he found it perfectly sweet.

M. Vauquelin, has recommended several means of preserving water, on long voyages. With this view, the inside of the casks was washed with lime-water, which changed into calcareous carbonate, and thus effectually prevented putrefaction. The same desirable object may be attained, by adding a small portion of vitriolic acid, and of alkali, to every cask; which will preserve the water in a pure and salubrious state, for at least twelve months. Charcoal has also proved to be eminently adapted to such purpose: the most advantageous mode of employing this substance, is that of charring the inner surface of the staves, previously to constructing the casks.

The latest method of preserving fresh water in a sweet state, is by Samuel Bentham. It consists simply in stowing water in wooden casks or tanks, lined with metallic plates, known under the name of tinned copper-sheets; the joinings of such cases being carefully soldered, so that the water cannot find the least access to the wood. These tanks may be manufactured of any shape, adapted to the hold of the ship, and thus contain any quantity of water; so that considerable stowage-room may be saved on board of vessels, which is at present occupied by the casks.

On the other hand, if water has become putrid, it may be divested of its pernicious properties, by boiling or by distillation; and by filtering it through machines described in the article Filtration.

To restore putrid water to its original purity, Dr, Lind directs a small cask, open at both ends, to be placed within a larger vessel, the head of which has been taken out: clean sand and gravel are then to be put into both vessels, so that the level of the sand in the inner cask, be higher than the bed in the intermediate space between the two barrels; sufficient room being left for pouring in the water. A cock should now be placed in the external cask, above the gravel or sand; and somewhat lower than the surface of the materials in the interior vessel. The water is poured in, at the top of the cask last mentioned; it sinks through the mass of sand; and, after passing through the bed in the intervening space, it ascends, so that it may be drawn off perfectly sweet and clear: when the surface of the gravel becomes loaded with impurities, it should be removed, and fresh sand be substituted.

According to the experiments of M. Lowitz, one and a half ounces of pulverized charcoal, and 24 drops of the sulphuric or vitriolic acid, are sufficient to purify three and a half pints of putrid or corrupted water, without communicating to it any perceptible acidity: he directs the oil of vitriol to be first mixed with the water; after which the charcoal must be added; but, if the sulphuric acid be omitted, it will be requisite to employ a triple

portion, or four and a half ounces of charcoal. When spring-water has acquired an unpleasant, hepatic flavour, it may be greatly improved by filtering it, through a bag with powdered charcoal. This substance may again be dried, and pulverized, when it will answer the same purpose a second time; and, if it lose its purifying effect, by repeated use, such property may be recovered, by making it red-hot in a close vessel.

WATER MILLS. } See MECHANICS.
WATER WHEELS. }

WATER PUMP. See ENGINE and HYDRAULICS.

WATER BLOWING MACHINE.—This is a contrivance so formed as to occasion a blast of wind, through an aperture at the top, placed in a horizontal direction, by the falling of water on a stone, placed at the bottom of the box. The water runs from a trough, then descends through a wooden tube pierced with a number of small holes, by which a quantity of air is taken down along with it, and is dashed against the stone placed at the bottom; the water is thus divided, the air is disengaged from it, and is pressed through the pipe before-mentioned, and directed on the burning fuel. While the air is driven in one direction, the water runs out through an opening at bottom.

The principal object in the construction of these machines, is to combine as much air as possible, with the descending current. With this view the water is often made to pass through a kind of cullender, placed in the open air, and perforated with a great number of small triangular holes. Through these apertures the water descends in many small streams, and by exposing a greater surface to the atmosphere, it carries along with it, an immense quantity of air, and is conveyed to the pedestal by a tube, open and enlarged, so as to be considerably wider than the end of the pipe, which holds the cullender.

It has been generally supposed that the water-fall should be very high, but Dr. Lewis has shown by a variety of experiments, that a fall of four or five feet is sufficient, and that when the height is greater than this, two or more blowing machines may be erected, by conducting the water from which the air is extricated, into another reservoir, from which it again descends, and generates air as formerly. That the air, which is necessarily loaded with moisture, may arrive at the furnace, in as dry a state as possible, the condensing vessel, should be as high as circumstances will permit; and in order to determine the strength of the blast, it should be furnished with a gage filled with water.

Franciscus Tertius de Lanis, observes, that he has seen a greater wind generated by a blowing machine of this kind, than could be produced by bellows 10 or 12 feet long.

For a particular description of this machine, see Ferguson's Lectures. See also the article TROMPE.

WATER, *how conveyed over hills, valleys, &c.*

The horizontal distance to which fluid will spout, from a horizontal pipe, in any part of the side of an upright vessel, below the surface of the fluid, is equal to twice the length of a perpendicular, to the side of the vessel, drawn from the mouth of the pipe, to a semicircle described upon the altitude of the fluid; and therefore, the fluid will spout to the greatest distance possible from a pipe, whose mouth is at the centre of the semicircle; because a perpendicular to its diameter, (supposed parallel to the side of the vessel) drawn from that point, is the longest that can possibly be drawn from any part of the diameter, to the circumference of the semicircle.

Fluids by their pressure, may be conveyed over hills and vallies, in bended pipes, to any height not greater than the level of the spring, from whence they flow. But when they are designed to be raised higher than the springs, forcing engines must be used. See HYDRAULICS.

It frequently happens that in the winter-season a supply of water is cut off, by the congelation of the water in the pipes; and the tubes themselves are often burst by the expansion that takes place, during the freezing of the included water. For remedying these inconveniencies, Mr. Wright of Kennington, England, recommends the application of an air-valve, by means of which, the conduit-pipes may be kept empty, when there is no occasion for a supply of water. For a description of this valve, and for farther information upon this useful subject, we must refer the reader to the Philosophical Magazine for July 1804, No. 74, page 147. English edition.

WATER PROOF. A term applied to certain stuffs, which have become either by a mechanical or chemical process, impervious to moisture.

The art of rendering cloth impermeable to water, has lately been practised to some extent. Vauquelin says, that a fluid effectual for this purpose, may be made

by dissolving soap and glue, in water; adding a solution of alum, which will occasion a flocculent precipitate: and then mixing with it a little dilute sulphuric acid, which re-dissolves the alumine in part, renders the precipitate lighter, and prevents it from falling down. He does not give the proportions, but observes, that there must not be too much acid.

The Chinese employ the following simple process, for rendering cloth water-proof.

Let an ounce of white wax be dissolved in one quart of spirit of turpentine; the cloth be immersed in the solution, and then suspended in the air, till it be perfectly dry. By this method the most open muslin, as well as the strongest cloths, may be rendered impenetrable to the heaviest showers; nor will such composition fill up the interstices of the finest lawn; or in the least degree affect the most brilliant colours.

We shall now enumerate several patents, which have been granted in Europe, for the same purpose.

In July, 1797, a patent was granted to Mr. Henry Johnson, for his invention of a vegetable liquid, the design of which is to bleach and cleanse woollen, or other stuffs; to prepare them for the reception of a certain compound, calculated to render them not only water-proof, but also more durable and elastic, when manufactured into articles of dress, which he terms *Hydrolaines*. In order to obtain first the vegetable liquid, the patentee directs horse-chesnuts, or the rinds and kernels of oranges, that are usually thrown away, or the offals and gall of fish, to be boiled for four or five hours; after which they are suffered to cool and settle, for a few days: in cases where these substances cannot be easily procured, eight quarts of water may be added to every pound of barilla, and the mixture allowed to dissolve for two or three days. Next, one pint of pearl-ashes, or of purified kelp, or wood ashes, must be added to either of these preparations; and, after the whole has been duly mixed, for 24 hours, a certain portion of lime is slacked in the compound, for the purpose of imparting the caloric; of precipitating the carbon of the ashes; and moderating the causticity of the liquor.—Now 40 quarts of water are to be boiled with one quart of fish, linseed or other oil; adding to this decoction, half an ounce of the salt of sorrel, or of sugar, or of the rectified salt of tartar; the object of which is to combine the oil with the water.—Lastly, after this composition has stood for 12 hours, it is to be strained, and one quart of such oily water, to be mixed with every twelve quarts of the liquid, prepared in the manner above described: when the mixture is completely settled, it forms, what the patentee calls a blanching lixivium.

The linen, woollen, cotton or silk stuffs, hats or leather, are to be immersed in lixivium, and extended on a frame. Caoutchouc is then to be dissolved in spirit of turpentine, (the smell of which may be dissipated, by the addition of equal parts of oil of wormwood, and spirit of wine,) so as to form a varnish; this liquor must now be applied to the wrong side of the stuffs that are to be prepared, by means of a solid piece of India rubber; and minute shreds of cloth, wool, silk or worsted, should be sifted over the varnish: in the course of two or three days, it will be perfectly dry; and the shreds, by their adhesion to the dissolved caoutchouc, will form a lining impermeable to water.

In 1801, another patent was granted to Messrs. Ackermann, Suardy and Co. for the invention of a process, by which every species of cloth may be rendered water-proof. As the patentees have not thought proper to publish, the particulars of their process, Dr. Willich observes, that we shall briefly remark, from our own observation, that their method appears to be a simple impregnation of cloth, with wax previously dissolved, and incorporated with water, by the addition of pure vegetable alkali or pot-ash. This being the cheapest and most expeditious mode of reducing wax to a fluid state, we are farther inclined to believe, that our conjecture is well founded; because all the woollen cloth, prepared in the manufactory of Messrs. Ackermann, Suardy, and Co. feels somewhat harder than such as has not been waxed; for the same reason, it will stand a shower of rain, only so long as it has not been subject to friction; and we understand from those, who have worn patent water-proof coats, that in the sleeves particularly, they are very apt to admit moisture through the different folds. Nevertheless, their process is entitled to attention; and it deserves to be adopted principally in those cases, where the manufacture is not liable to be impaired by friction; such as coverings for tents; for horses exposed to the rain when at rest; and especially for paper in which gunpowder, or steel and other goods, are to be packed.

Mr. Bellamy's invention for making all kinds of leather water-proof; consists of two compositions, which are prepared in the following manner.

First Method.

One gallon of nut-oil, and an equal quantity of poppy-oil, are to be mixed with three gallons of linseed-oil, or one gallon of nut, or poppy-oil, may be added to three of that expressed from linseed: or, two gallons of the latter may be combined with one pint of nut, and a similar quantity of poppy-oil. These ingredients (in the proportions above mentioned, or such as the nature of the oil may require,) are to be poured together into an earthen pot, and placed over a gentle fire: to each gallon of oil, must be allowed one pound of white copperas, sugar of lead, colcothar, or any other drying substance. The whole is to remain for the space of six or seven hours over such a degree of heat, as it will bear without rising, till it become sufficiently dry; when it may be taken off; and, as soon as it is cool, the compound will be fit for use.

Second Method.

Gum resin, one pound; pitch half a pound; tar of turpentine, of each 4 ounces, are to be added to one gallon of the oils prepared, according to the first method: these ingredients are to be well mixed with the oils, first by gently heating the whole mass, then increasing the fire, till the whole become thoroughly incorporated. The patent specifies various proportions, in which the ingredients may be used; but experience will be the best guide to ascertain them.

When the oils, prepared conformably to the first method, or the gums, &c. according to the second, are sufficiently cool, Mr. Bellamy directs a brush to be dipped in the preparation, which should be rubbed into the leather. As soon as that article is thoroughly impregnated, it ought to be laid on an even board and the superfluous matter removed from its surface With respect to sole leather, or similar thick substances, he observes, that they should first be gently warmed; the composition is then to be applied till they are fully saturated; and after being properly dried in a warm place, they will be ready for use.

In the *Memoirs of the Academy of Sciences of Turin*, for 1789, we meet with an interesting communication by M. de St. Real; on the means of rendering leather (especially that destined for soles,) impermeable to water, without diminishing its strength. This object, he conceives, may be effected, without any alteration in the usual method of tanning, by the common operations of currying; provided the skins be compressed in certain heavy rollers, after being previously immersed in beef-fat, or oil. The additional greasing, and pressing, will not greatly increase the price of sole leather; which, after being a whole year in tanning, imbibes water in a much smaller proportion than cow-leather, when dressed with fat. We regret that our limits do not permit us to specify the very ingenious experiments, made by M. de St. Real; as we are convinced, they will contribute to improve the art of tanning.

Another method of preventing leather from being penetrated by water, consists in exposing it with the flesh-side towards the fire: after which, a coat of warmed tar is to be applied with a proper brush, three or four times successively, according to the thickness of the leather, till the liquid matter penetrate through the whole skin. The durability and strength of shoes, &c. will be considerably increased, if, in laying on the last coat of tar, they be sprinkled over with a small quantity of fine iron-filings, which will, in a manner, fill up the pores of the leather. Lastly, shoes may be rendered impermeable to moisture, by occasionally rubbing the soles with hot tar: thus the feet may be preserved dry and warm: an important object in this climate, especially during the winter season.

The fishermen of New-England preserve their boots water-proof, by the following composition: One pint of boiled lint-seed oil, half a pound of mutton suet, six ounces of pure bees-wax, and four ounces of rosin. These ingredients are melted together over a slow fire, and the boots or shoes, when new and quite clean, are warmed, and rubbed with the composition, till the leather is completely saturated.

There is an improved composition for preserving leather, the good effects of which, are sufficiently ascertained. One pint of drying oil, two ounces of yellow wax, two ounces of spirit of turpentine, and half an ounce of Burgundy pitch, should be carefully melted together over a slow fire. With this mixture new shoes and boots are rubbed either in the sun, or at some distance from a fire, with a sponge or brush: the operation is to be repeated as often as they become dry, until they be fully saturated. In this manner, the leather becomes impervious to wet; the shoes or boots made of it, last much longer than those made of common leather; acquire such softness and pliability that they never shrivel, nor grow hard and inflexible; and, in that state, are the most effectual preservatives, against cold and chilblains. It is, however, necessary to

remark, that shoes or boots, thus prepared, ought not to be worn, till they have become perfectly dry, and elastic; as, in the contrary case, the leather will be too soft, and wear out much sooner than even the common kind.

In "*An Essay on Shooting*," the following composition is given.

Tallow, half a pound.
Hog's lard, 4 oz.
Turpentine,
New bees wax, } 2 oz. each.
Olive oil,

To be melted by a gentle heat, and rubbed on the leather (when free from dampness,) the night before the shoes or boots are wanted.

Mr. Johnson, of New-Brunswick, has given the following receipt.

Take five parts tallow, seven ditto bees-wax, twelve ditto size, one ditto brown soap, four ditto lamp-black; incorporate the whole over a fire, (adding the ingredients one by one, and stirring the mass well,) then make it into cakes.

The size is either glue dissolved in water to a jelly, or else strong jelly made of gum tragacanth in water; or a jelly made by boiling glue pieces (bought of tanners) in water, to a proper consistency, and strained.

Blacking made agreeably to the foregoing receipt, feeds the leather, and when brushed bright, gives it the colour and appearance of new leather. It is also best adapted for cleaning ladies' Morocco shoes: and, if it be required to make it more shining, more size may be added.

Several receipts, for the same purpose, may be found in the Sporting Magazine, and in Tilloch's Magazine.

WAX. There are two or three substances which resemble each other so closely, as to have received the name of wax. The first, and by far the most important, is *Bees Wax*, which is consumed in such vast quantities for giving light, and is also used for a variety of other purposes. Another kind of wax is the myrtle wax, which is extracted pretty largely in Louisiana, and some othe parts of our country, from the *Myrica Cerifera*. Another substance very similar to wax is the *Pe La*, of the Chinese, the product of an insect, the exact species of which is not known; and the white matter which yields the Laccic acid, has also a strong resemblance to wax.

The properties which all these substances have in common, are fusibility at a moderate heat; when kindled, burning with much flame; insolubility in water, solubility in alkalies, and also in alcohol and ether. In these two latter properties all the species of wax differ from the concrete oils, with which in other respects they have a very strong resemblance.

Bees Wax is the substance, excreted from the body of the bee, of which these insects construct their cells, both those for containing honey and for the lodgement of their young. It is collected for the use of man wherever bees are kept. A young hive will yield at the end of the season about a pound of wax; and an old hive about twice as much. The colour of wax, when fresh from the bee, is nearly white, but it soon grows considerably yellow in the hive, or if very old is of a dark brown. The origin of the wax we shall mention afterwards. The finest wax is found to be made in dry, healthy, or hilly countries, but it is decidedly inferior, in parts full of vineyards. The loaves of common bees wax are made immediately from the common honey-comb, by a slight preparation. The combs are first emptied of all the honey that can be collected by the press, and are then either soaked for some days in clear water, to extract all the remaining honey, or in some parts they are broken down and spread on a sheet in the neighbourhood of the hives, and in time the bees suck out all the honey that is left, and reduce the wax to small pieces like bran. The whole of the wax is then melted in a clean copper, with boiling water, and strained by a press through cloth bags, to free it from every impurity. It is then cast into cakes, in which form it is received by the wax-refiners.

The wax of these cakes, which is the ordinary bees wax of the shops, is a pale yellow substance, of an agreeable honey-like smell, soft, and somewhat unctuous to the touch, but without sticking to the fingers, in winter becoming considerably hard and tough, and melting at about 142°.

This yellow colour and the smell of wax are entirely taken away by exposing it, when divided into thin laminæ, to the united action of the light and air, and by this means it becomes perfectly white, scentless, somewhat harder and less greasy to the touch, and in this state it is employed for candles and many other purposes. The process of bleaching wax is the following: The yellow wax is first broken into small pieces and melted in a copper cauldron, along with a very little water, just sufficieut to prevent the wax from burning, for it is of importance to use no more heat than is necessary. The plug of the copper is then drawn, and

the melted wax and water fall together into a vessel below, where it is covered with a thick cloth, to keep in the heat for some time, that the water and impurities may settle. The clear melted wax is then suffered to flow into a vessel with the bottom full of small holes, about the size of a grain of wheat, whence it falls in small streams upon a cylinder kept constantly revolving over water, in which it partly dips, by which the wax is immediately cooled, and at the same time drawn out into thin shreds or ribbands. These shreds are then spread upon cloths stretched on large frames, which are supported a foot or two from the ground, and after exposure to the sun and air for several days, with frequent turning, their yellow colour nearly disappears. The half-bleached wax is then heaped up in a solid mass, and allowed to remain for a month or six weeks, after which, to give it complete whiteness, it is re-melted, and ribbanded, and bleached as before, till it is entirely void of colour and smell. Some manufactures add in the re-melting, either alum or cream of tartar, or sometimes milk, all of which are supposed to increase the whiteness and solidity of the wax.

Instead of spreading the ribbands of wax on cloths, some employ a broad course of bricks laid evenly, which are frequently watered to prevent the wax from melting by the heat of the sun absorbed by the bricks.

Although the bleaching of wax is generally, if not always, performed in the air, by the assistance of the sun and moisture, yet the operation may be considerably facilitated by means of oxymuriatic acid, or the saline combinations formed with this acid. For this purpose, the acid is prepared as formerly directed in the article on bleaching, and in the appendix to Vol. 1. and the wax after having been reduced in the manner before stated, may be put into it, or in the solution of the oxy, or hyperoxy muriatic acid, and in a few hours will be completely bleached. The expense of bleaching required, is not so considerable; and we think it economical, when it is considered that the process may be performed at all seasons of the year, and the facility with which the operation is finished.

Wax is frequently adulterated by tallow, suet, or animal fat of some kind or other. This gives the mixture a great fusibility, so that when ribbanded and exposed to a hot sun, it is extremely apt to cake. It also takes away from it the semi-transparency, which is a distinguishing property of pure bleached wax; for though fine tallow is full as white as wax, it is always a dead opake white. The adulteration may also be detected by boiling alcohol, which dissolves wax but not tallow.

Bleached wax burns with a very pure white light, and gives no offensive smell, and very little smoke compared with tallow. Being less sensible than tallow, it requires a smaller wick. Bleached wax melts at about 155° or 7° higher than the unbleached. Its specific gravity is less than that of water, being about .96.

Alcohol has no sensible action on wax when cold, but on boiling this fluid, it dissolves rather less than one-twentieth of its weight of wax.

Sulphuric ether dissolves wax when a little heated.

When wax is boiled in caustic potash, the fluid becomes turbid, but after a time most of the wax rises to the surface, and in a flocculent form.

Pure ammonia acts nearly as the fixed alkalies.

If wax is distilled with a greater heat than that of boiling water, it is decomposed.

As the distillation advances the acid becomes stronger, and the oil much more copious and thicker, till at last its consistence is such as to become solid in the receiver, when it is called *Butter of Wax.*

The essential oils dissolve wax but sparingly.

The action of the acids upon yellow wax, has been examined in a series of experiments by Beckman, particularly with a view to their bleaching power. The same subject has also been followed by Sennebier, who has added some remarks on the effect of light and other supposed decolouring agents.

The operation of light was thus shewn: some yellow wax was melted and thinly spread on a plate of glass; a similiar plate was laid upon it when hot, and the edges of the plates were closed with sealing wax. The bees wax therefore was deprived of the access of air, and it was placed in the sun, and exposed to its light for four or five days daily. Another quantity of wax was inclosed between plates in a similar manner, but kept in the dark. In two days the wax kept in the sun, began to bleach, and in a month's time the whole, where it did not exceed two lines (one sixth of an inch) in thickness, was quite white, whilst no change whatever took place in that which was kept in darkness.

If thin shavings of wax are immersed in either of the three mineral acids, a lit-

tle dilute, in a few hours the yellow colour disappears, and the wax is rendered partly white, partly pellucid. No further change takes place, nor is the colour of the acid at all altered (unless heat be applied) for many weeks. The bits of wax are, however, much hardened by remaining in the acid, so as to rattle when shaken against the sides of the glass, and by a brisk agitation they may be broken down into very minute white flocculi. This change takes place much the most rapidly in the nitric acid, or in the nitromuriatic, and it is completely effected in an hour or two. It also happens when wax is melted in nitric acid, though less rapidly. This circumstance led the author of these experiments to hope that something might be done in the large way in bleaching wax by nitric acid, but this hope proved fallacious, for on removing the wax from the acid, and melting it in water, (which is necessary to extract the acid) the wax resumes a yellow colour, and the water also becomes of a high brown yellow. By repeatedly melting the wax in water (without any additional acid) it becomes more and more yellow, and at the same time grows harder, and much more fusible than at first.

Neither is the vapour of burning sulphur, which so speedily bleaches silk and many other substances, more successful in depriving wax of its colour.

Professor Beckman then tried the whitening effect of fuller's earth, or some similar substance, being led to use it from the known power which it has in whitening and purifying tartar. Some yellow wax was melted, and a quantity of this earth finely powdered, was sprinkled in. The wax was then melted out, and being fused in water, it appeared grey, like wax half bleached in the common way, which the author supposes would save much time in the whole process.

A few words may be added as to the origin of wax. It is usually supposed that the wax is the *pollen* of flowers, which the bees visibly collect on their thighs, and afterwards elaborate in some unknown way. The great difference between wax and this matter, which the bees collect, has however been long remarked. When examined by the microscope, this little mass of pollen is obviously composed of a number of hard grains compressed together, and if it is laid on a hot plate, it does not melt as wax would do, but smokes, dries and is reduced to a coal, and if kindled it burns without melting.

Some late very curious experiments of Huber, one of the most celebrated apiarists in Europe, has further shewn that the pollen has no share whatever in the formation of wax, but that this latter substance is produced indiscriminately from honey, sugar or any other saccharine matter which serves as food for the bees.

The *Myrtle Wax* is a concrete substance, moderately hard, nearly of the consistence of bees wax, and of a dingy green colour. It is contained in abundance in the berries of the *Myrica latifolia*, a fragrant bushy shrub, with leaves like the myrtle, which grows abundantly in many parts of North America; it is also procured from another species of the same genus, the *Myrica Gale*, which is common in boggy mosses in several counties of England.

A very large quantity of the myrtle wax is extracted from this shrub in Louisiana, by collecting the berries, boiling them with water, and bruising them at the same time, by which the wax melts out and rises to the top, as a thick oily scum, which is easily separated. The berries yield about a fourth of their weight of this wax. They contain also, according to M. Cadet, a considerable quantity of gallic acid.

This wax has been examined chemically both by the above-mentioned chemist and Dr. Bostock, and it is found to resemble bees wax so closely, in the most important properties, that they may be classed under the same genus of chemical bodies.

No attempts have yet been made to bleach it in the large way, by exposure to the sun and air.

The myrtle wax is used largely in some parts of the United States, as a material for candles, and on the whole it appears worthy of further attention.

WEATHER-GLASS, or barometer. See METEOROLOGY.

WEAVING. The art of plain weaving is so well understood in every part of the country, that we presume it quite unnecessary to enter into the detail of a process, which is known to almost every house-keeper. We shall therefore, on this part of the subject, content ourselves with some general observations, which we have taken from a work of standard merit. In describing the faults to which cloths are subject, in consequence of bad weaving, our author says:

"When from any cause the weft is not regularly interwoven with the warp, a deficiency must happen in the cloth, which is called by the weavers a *scobb.* This may proceed from several causes: the most frequent, is some obstruction in

the warp, which prevents any portion of it from rising or sinking regularly when the shed is formed; of course the shuttle, instead of passing fairly between the threads of the warp, passes either over or under the portion which is obstructed, and the weft, at that place, is not at all interwoven with the warp. A knot or lump upon the warp, if not picked away in the dressing, will often obstruct two or three threads, and form a small scobb. When the weaver, from inattention, continues to weave, after a thread of warp has been broken, it very frequently crosses between a number of the threads nearest to it, and, by obstructing the shed in that place, will cause a large scobb. Scobbs are also sometimes produced by the lay being too low hung, but this is more frequent in weaving with the hand shuttle than with the fly. In this case, the scobbs are always near the list or selvage of the cloth.

A second fault in cloth is known, among weavers, by the name of a *jisp*. This is most frequent in light fabrics, and is occasioned by any particular thread or weft not being struck up so close as the rest. Jisps are very frequently occasioned by defects, either in the construction or mounting of the loom. If either the yarn beam, or cloth beam, are not turned very true, jisping will be unavoidable. Or if either the heddles, or the lay, be not hung parallel to the beams, the same defect will ensue. If the loom is correctly made and mounted, the fault must be with the weaver, and this is only to be surmounted by attention and practice.

The other faults in cloth, generally proceed from inattention in the management of the warp or weft. If threads are inaccurately drawn through either the heddles or the reed, the defect will be apparent in the cloth.

There is nothing which adds more to the beauty of cloth of every description, and about which good weavers are more solicitous, than a tight uniform selvage. In order to produce this, the warp must be dressed, even with greater care than what is necessary in the middle of the web. The tightness of the weft also, contributes materially to the beauty of the selvage. It is, sometimes, the custom, to warp a few splitfuls at each selvage, with coarser yarn than the body of the web. In many kinds of cloth, however, the common practice is, to draw the threads which form the selvage, double. That is, to draw two threads through each heddle.

The threads, which form the warp of the selvages, being coarser than the rest, and, also, being more drawn towards the middle of the web, by the weft, the splits of the reed, through which they pass, are apt to be worn much sooner than the others. A weaver should carefully attend to this, for if the reed is injured, the work cannot be good. When cane reeds are used, and when the webs wrought in them are, generally, of the same breadth, it is now very common to make those splits, through which the warp of the selvages passes, of brass.

It is unnecessary to enumerate further, the defects which may occur in the weaving of cloth, for no instructions can altogether supply the want of that skill, which is only to be attained by practical experience.

Tweeling.

This species of weaving, which, probably, derives its name from the French word *touaille*, a hand towel, is, almost exclusively, confined to thick fabrics of cloth. The application of it is very extensive, and it is much used in the manufacturing of cloth from each kind of material. It possesses also this advantage, that, besides forming a species of ground, it is applicable to an infinite variety of ornamental decoration. To the investigation of the first of these properties, we will, for the present, confine ourselves.

In analysing the fabric of plain cloth, *it is found* that every thread of the warp and the woof, cross each other, and are tacked together alternately. This is not the case in tweeling, for in this manufacture only the third, fourth, fifth, sixth, &c. threads cross each other, to form the texture. Tweeled cloths have been fabricated of many different descriptions. In the coarsest kinds, every thread is crossed: in finer fabrics, they cross each other at intervals of 4, 5, 6, 7, or 8 threads; and in some very fine tweeled silks, the crossing does not take place until the 16th interval.

Before proceeding further, it may be proper to explain what is known, among weavers, by the appellation of *flushing*. When any thread, or portion, whether of warp or woof, is not regularly interwoven with the fabric, as in plain weaving, that thread, or portion of threads, is said to be flushed. By referring to Fig. 2. Plate 24. this will be better illustrated than by any description.

In Fig. 3. is a specimen of plain cloth, as it would appear when viewed through a microscope, the intersections of the threads are evidently alternate. Fig. 2. may be considered as a representation of tweeled cloth, upon the same principle

that Fig. 3. represents plain cloth. This figure will show, that the same thread of woof remains flushed, or disengaged from the warp, while passing *over* three threads and is tacked down by passing *under* the fourth. Now were this cloth turned upside down, the same appearance would take place in the warp. That is to say, every fourth thread of warp would be interwoven with the woof, and the remaining three threads would be flushed. An inspection of the figure will also evince, that the threads, both of the warp and woof, are interwoven in regular succession, and at regular intervals.

To produce these effects, a number of leaves of heddles is required, equal to the number of threads contained in the interval between each intersection, *inclusive*. Thus, when every third thread is to be interwoven, three leaves are required: if every sixth thread, six leaves will be necessary, and so of all the others. For this reason, the different species of tweels are distinguished by the number of leaves which are requisite in weaving them; as a four, a five, or a six *leafed* tweel, &c. The specimen in Fig. 2. is a four leafed tweel.

Tweeling is, in many instances, applied to the weaving of cloths which require a great portion of strength, thickness, and durability.

For instance, in the linen manufacture, every description of bed and table linen, is generally tweeled; sometimes with ornaments, and sometimes without them. In the silk, tweeling is very common. Sometimes it is employed for the sake of strength, but more frequently for the display of colour. In the woolen, strength is the general object; and in the cotton, it is most commonly the same.

It may be necessary in this place, to inquire shortly into the causes which render tweeled cloths stronger than plain, and to ascertain the difference.

In so far as the strength of tweeled cloths depends solely on the mode of weaving, that strength will be rather diminished than increased, when compared with plain cloth, containing an equal quantity of similar materials. For, in the texture of plain cloth, every thread is constantly interwoven; whilst in that of tweels, they are only interwoven at intervals. Now, in the latter case, the threads can derive no mutual support from each other, except at the intervals where they are interwoven; and that part of them which is flushed, must depend entirely on the strength of the individual threads; those of the warp being flushed upon one side, and those of the weft upon the other.

The following inference will naturally arise from this. Let two webs of equal length, equal breadth, and equal in the quantity, quality, and fineness of the yarn, be woven. Let the first be plain, and the second tweeled. The quantity, quality, and fineness of the materials being equal, their strength ought to be so also. But, if by *strength*, we understand that quality, which opposes the most effectual, and most continued resistance to the decay of cloth, from common wearing: the tweeled web (if equally used) would be in tatters, long before the plain one was materially injured. This is the idea commonly, although inaccurately, attached to the word strength, when applied to the fabric of cloth; and, indeed, the above remark will not be found universally true, for the durability of cloth, exposed only to common wearing, depends partly upon its strength, and partly upon its flexibility.

It is not, therefore, in the effect of the mechanical operation, but in the facility of combining a greater quantity of materials in the same dimensions, which this mode of weaving affords, that we are to look for superior strength or durability. This may be easily illustrated. When the shed of any web is opened, every thread, either above or below the thread of woof, which has been driven through the web, will oppose a certain resistance to the operation of the lay in driving the shot home; and the sum of all these resistances will be the whole resistance. Now, in plain weaving, every thread is interwoven, and therefore opposes its portion of resistance; whereas, in a *four leafed tweel*, every fourth thread only is interwoven, and, of course, gives resistance. The ratio of resistance, therefore, will be *inversely* in proportion to the number of leaves in the tweel, compared with unity.

In the warp, the friction in the reed will be diminished in the same proportion; for each thread, instead of changing its place at every shot, changes only once in every four shots. Consequently, much more warp may be crowded into the same space without injury, than could be done in plain weaving.

From the above, we may safely deduce, that the strength, or durability, of a tweeled web will be somewhat less than the proportion of the materials which it contains, will be to that of a plain web, supposing each to be of equal strength and quality.

But, when the fabric is very close,

tweeled cloth possesses another advantage over plain, in point of durability. When the warp of plain cloth is very much crowded in the reed, and the weft driven very closely home, the threads, in order to cross each other alternately, must deviate very materially from their natural form, which is a straight line; whereas, when woven, they become serpentine. This renders the cloth very liable to be easily cut, or chafed, especially when composed of hard, and comparatively inflexible materials. This defect is chiefly observable in stout linens, and arises from the inelastic, and inflexible nature of the fibres of the flax. But when tweeled, as the threads only cross at intervals, the deviation from the straight line is much less, and the flexibility of the cloth, of consequence much greater.

Carpets must be Wove in the Draw Loom.

I shall therefore, before proceeding, endeavour to describe and illustrate the principle and construction of this extensive and useful machine, and to trace the differences which generally subsist between those which are used for double cloths or carpets, and those employed for the manufacture of damasks, which are fancy weels of the most extensive range of pattern. Draw looms, are used for spot weaving, when the pattern is extensive; but the construction of these differs very little from the others, and the small deviations, shall be noticed in their proper place. I preferred postponing the description of the damask draw loom, until I could also introduce that for carpets; both for the sake of tracing the analogy between them, and to afford further oportunities, of extending my inquiries and examinations, respecting these machines, which are, by much, the most complicated used, by weavers.

It would be difficult, if not impossible, to give representations of the full mounting of an extensive draw loom, for the number of cords are so immense, and they are necessarily placed so close together to save room, that it would create unnecessary confusion, to attempt to delineate the whole. I have lately seen a damask draw loom at Dunfermline, where the manufacture is carried to great extent and perfection. This loom, which I was assured was not the most extensive in the place, contained 120 designs of 10 spaces each, and consequently, was adapted to work a pattern, as extensive as could have been effected by 1200 leaves, upon the plan of the back harness. I have therefore, represented specimens of the working parts upon a limited plan, for the most extensive are only continuations of the most limited, in the same regular succession.

These plans will be found in Plate 21.

The use of the draw loom, is to combine much mounting in a small space; consequently the shafts, and every other part which is composed of wood, are avoided, and the moving apparatus consists entirely of cordage. That part of the apparatus which serves as a substitute for the heddles of other looms, is called the harness, and passes through a flat board, containing a number of holes, or other divisions. In Fig. 1. the edge of the board is represented at C, and the harness passing through it at H. The figure is a transverse elevation of that part, which is peculiar to the draw loom, the front leaves, which are worked by treddles, and all other parts in front, being taken away, for the purpose of shewing these parts. In the draw loom, the draught of the warp through the mails of the harness, is always in uniform succession, as in tweeling; but it is customary to draw a number of threads through the same mail, as in the back harness used for the diaper. Indeed, the draw loom harness is merely an extension of the former, effecting the same end by different means. Fig. 2. is a representation of the flat side of the board, the edge of which is seen in Fig. 1. to show the way in which the holes, or divisions, through which the harness passes, are placed. Near the centre of each twine of the harness, is the copper or pewter mail, which serves as the eye, and each is kept tight by a small weight, (generally of lead) hung to the bottom. Now, if we are to suppose, that the range of the pattern is 100 spaces of the design, for 1000 or any number, is only an extension of the same principle, then the 1st, 101st, 201st, &c. twines, after passing through the board, are to be knotted together, because all rise at once, each being the first of a new design. In like manner, the 2d, 102d, &c. are knotted, and so on until the whole succession of 100 is completed. To each of these a cord is then tied, which after passing over a pully in the box A (containing in this case 100 pullies,) is fastened, in a horizontal direction, to a fixture on one side of the loom, and nearly level with the box A. The horizontal part of these cords is marked B, and this part of the mounting is called the tail.

To each cord in the tail, another cord is tied at a convenient distance on one

side of the loom, and passes perpendicularly towards the floor, near which they are all made fast to a cross piece of wood. These cords are called simples, and are distinguished by the letter D. Another stout cord F, is then stretched from the roof to the floor, parallel to, and at a small distance from the simples. These operations being performed, the whole must be made uniformly tight, and care must be taken that all the mails are level, and of a proper height. The warp is then to be drawn through the mails, and front mounting; successively, as before mentioned, and the remaining parts for lifting the harness to form the design, are to be applied.

If the connection from the harness to the simples is traced, it will be evident that when any simple is either pulled down, or strongly to one side, it will raise all the twines and mails, with which it is connected; and, when relieved, they will be pulled back to their former places, by the weights which are fastened to each. As the simples are very numerous, and close to each other, it would be impossible, in a heavy design, to select those which should be successively pulled, without a great waste of time, unless means of regular and speedy selection are employed. This is effected by means of another set of cords called lashes, represented at E, and connecting the simples with the cord F, upon both of which the lashes slide easily up and down. The application of the lashes to the simples, must be regulated by the pattern to be produced, and this is called

Reading on the Design.

This operation, from the complexity of the patterns, and the necessity of accuracy, is generally performed by two persons. The pattern, being drawn upon design paper, points out what mails are to be raised, or which is the same, what simples are to be pulled at every change of the harness. It is the business, therefore, of one person to read, or rather to select, from the paper what simples are to have lashes, applied to them at every change. The other person, following the instructions which he receives, passes a lash round every simple, which is pointed out. He then knots the lashes together, and connects the other end with the cord F, by a loop round it, so that the lashes may slide freely upon it. The other end passing loosely round each simple, also slides freely upon them. The lashes must be uniformly tied, that the simples may be pulled equally. A single instance will be sufficient to illustrate how the design is taken from the design paper.

Let Fig. 4. Plate 24. represent the design of a flower, any number of which are to be woven, at certain intervals, by the draw loom. By counting the spaces upon the design paper, it will appear that this flower covers 45 by the breadth, and 35 by the length. The former gives the number of mails in one flower; and the latter, the number of changes which the harness must undergo while it is working. When the warp has been regularly drawn, and the simples applied, the lashes are to be placed according to the design. In this case, every square which is black, represents a simple to be raised. Beginning at the bottom, it appears that only two mails are to be raised for the stem of the flower, and counting from the right hand, these will be raised by the 31st and 32d simple. The instruction, therefore, given to the person who applies the lash is; Pass 30 and take 2. On the second row of squares, part of the flower as well as the stem, must be raised, and by counting as before from the right, passing the white, and taking the black, the direction will be; Pass 18 take 3; pass 8 and take 2. On the third, two other parts come in: therefore, pass 10, take 3; pass 5, take 5; pass 7, take 2; pass 7 and take 4. In the same way, the operations are continued, until the whole 35 are completed, always passing the white and taking the black.

I shall add the whole instructions for this flower, by comparing which with the design, the principle may be sufficiently understood, and all damask patterns, however extensive, are done exactly on the same plan.

1st, Pass 30 and take 2.

2d, Pass 18, take 3; pass 8 and take 2.

3d, Pass 10, take 3; pass 5, take 5; pass 7, take 2; pass 7 and take 4.

4th, Pass 9, take 5; pass 4, take 5; pass 6, take 3: pass 6 and take 6.

5th, Pass 8, take 7; pass 3, take 5 pass 6, take 4; pass 4 and take 7.

6th, Pass 8, take 7; pass 4, take 3; pass 6, take 2; pass 2, take 2; pass 2 and take 8.

7th, Pass 8, take 7; pass 4, take 2; pass 6, take 3; pass 2 and take 11.

8th, Pass 9, take 5; pass 5, take 2; pass 5, take 4; pass 2, take 2; pass 3 and take 4.

9th, Pass 10, take 3: pass 8, take 2; pass 2, take 4; pass 4 and take 2.

10th, Pass 11, take 2; pass 10, take 2; pass 2, take 2; pass 4 and take 2.

11th, Pass 11, take 2; pass 10, take 2; pass 2, take 2; pass 6 and take 2.

12th, Pass 13, take 3; pass 3, take 3; pass 4, take 2; pass 6 and take 5.

13th, Pass 16, take 4; pass 5, take 2; pass 8 and take 8.

14th, Pass 25, take 2; pass 8 and take 9.

15th, Pass 24, take 2; pass 10 and take 9.

16th, Pass 8, take 3; pass 13, take 2 pass 11 and take 8.

17th, Pass 7, take 5; pass 11, take 2; pass 14 and take 6

18th, Pass 7, take 6; pass 9, take 3; pass 16 and take 3.

19th, Pass 7, take 6; pass 8, take 4.

20th, Pass 7, take 6; pass 7, take 5; pass 7, take 4.

21st, Pass 1, take 3; pass 4, take 5; pass 6, take 2; pass 2, take 3; pass 5, take 6.

22d, Take 6, pass 3; take 4, pass 4; take 3, pass 3, take 14.

23d, Take 7, pass 3; take 2, pass 5; take 2, pass 3; take 9.

24th, Take 8, pass 2; take 2, pass 2; take 2, pass 8; take 2, pass 3; take 7.

25th, Pass 1, take 13; pass 10, take 2; pass 5, take 4.

26th, Pass 2, take 5; pass 3, take 4; pass 10, take 2.

27th, Pass 10, take 2; pass 2, take 4; pass 7, take 2.

28th, Pass 8, take 4; pass 2, take 6; pass 5, take 2.

29th, Pass 7, take 5; pass 3, take 6; pass 5, take 6.

30th, Pass 7, take 5; pass 3, take 6; pass 5, take 8.

31st, Pass 6, take 6; pass 3, take 6; pass 6, take 8.

32d, Pass 6, take 5; pass 5, take 5; pass 6, take 8.

33d, Pass 6, take 5; pass 6, take 3; pass 8, take 7.

34th, Pass 6, take 5; pass 19, take 3.

35th, Pass 7, take 3.

From this it will appear, that the shape of every pattern wrought in the draw loom, depends entirely upon the mode of connecting the lashes and the simples.—Of course, the pattern may be altered at pleasure, to any other which does not exceed the range of the mounting, merely by changing the order of this connection. It will also be obvious, that in ascertaining the order from the design paper, the connection of the lashes with the simples, is denoted by counting from right to left, or *vice versa*, and that the number of changes, and consequently the number and arrangement of sets of lashes, on the cord F, is, in like manner, ascertained by counting the design, from the bottom to the top. The first set is generally placed lowest upon the cord, and the rest in regular succession above it. The sets are connected with each other, at convenient distance, by pieces of twine; so that by a slight pull, they will follow each other in regular order. When the connections are completed, all the sets are pushed up nearly to the top of the cord F. The loom is then to be worked by two persons, one of whom pulls the draught, and the other manages the treddles, shuttle, and lay. The fore mounting is exactly the same, in every respect, as the diaper harness, and the number of leaves equal to one set of the tweel. For the ordinary qualities of damasks, five leaves are commonly used, but many of the finest are wrought with eight.

When the operators are ready to begin, the person who draws, pull the first set of lashes down, and then by drawing the simples, and consequently the tail, raises that part of the harness, attached to the part which is pulled. The weaver then works, until a change of the harness becomes necessary. The person who draws, then slacks the simples which had been drawn, pulls down the second set of lashes and draws the simples as before; the weaver proceeds to work until another change is required, and so on until the whole pattern is completed. In the design given, the weaver is to work once over his treddles between every change, and this is generally the case in damask weaving.

When the mounting of the draw loom is very extensive, it is found convenient to have two, and sometimes three boxes of pullies; for were the whole number of pullies placed in one box or frame, it must be extended to a very inconvenient size. These are placed parallel to each other, as represented by the dotted lines, in Fig. 1. Pl. 21. and an equal portion of the cordage is conducted over each. It is also common, to have three or four different sets of simples, and lashes. One set of these is stretched, and the others are loose; and each set is stretched in turn, when a different part of the pattern is to be wrought.

" Many different attempts have been made, at various times, and with various success, to supersede the necessity of employing an additional person to draw the lashes, by constructing the apparatus so, that the weaver may draw the harness, as well as work the treddles. The most recent, and probably the most generally adopted of these plans, is one which has been lately invented and in-

troduced at Dunfermline, where it is now very common. It is known there, by the name of the

Patent Draw Loom.

In this loom, the tail of the harness, instead of being carried over pullies to one side, extends perpendicularly upward, and is fastened to the roof of the shop. Upon each cord is a knot, at a convenient distance from the roof, and all the knots must be at an equal heighth. The simples extend horizontally over the weaver's head, where they are made fast; and the lashes hang down from these, and have generally a small handle, or bob, as it is frequently called, attached to each. An instrument, called the *comb*, from its figure, is hung in a horizontal position, and moveable on its centres. The appearance and shape of the comb will be found in Fig. 4. Pl. 21. which represents it as it appears when viewed from above or below. In Fig. 5. it appears as viewed on one side. In both these figures a represents the centres, b the teeth, c the pull, d a few cords representing the relative situation of the tail of the harness to the comb, e cords representing simples, and f Fig. 5. the situation of the lashes. In Fig. 5. the operation is represented by two cords of the tail d, one of which has the knot drawn into the teeth b, and the other is disengaged. When the weaver pulls down any particular set of lashes, those simples to which they are attached, are drawn into the oblique direction, as at e, and, consequently, pull those cords of the tail to which they are tied, between the teeth of the comb. The end of the lever projecting at c, being then pulled down, and secured by a knot in a notch, in the same way as the diaper harness mounting, the teeth rise, and by means of the knots, carry up that part of the harness which is drawn betwixt the teeth, whilst all the rest remains free. When a change is wanted, the comb is let down, and the simples being slacked, the cords of the tail quit the comb; another set is drawn in by pulling another set of lashes, the comb is again raised and secured as before, and the operation proceeds. The weaver pulls the lashes with one hand, and raises the comb with the other, so that very little time is consumed in changing the harness.

The patent draw loom seems to possess some very obvious advantages, which are not to be found in the old loom. It saves the labour of an additional person, and the operation seems to be conducted altogether, or nearly, as quick. 2dly, Both the tail and simples are much shorter, and, consequently, require less cordage: the boxes or frames of pullies are unnecessary, and the space occupied by the simples at the side of the loom is saved: and 3dly, The mechanical apparatus is so applied, that much less power is required to raise the harness, which must be of considerable advantage in heavy mounted looms, where the strength required is very considerable.

By reducing the way in which the power applied in both cases, to the elementary principles, the difference will be found to he very great. In the first case, one end of the tail is made fast, and the other sustains all the weights attached to the harness. The simples which are pulled down to raise the harness are connected to the tail, between the end which is fast and the pullies. Consequently, the simples act in the same *ratio*, as a weight fixed to a moving pully, suspended by a rope passing through the pulley, and of which rope one end is made fast. It has been often demonstrated, that a weight, say of 2 lbs. in this situation, will be balanced by another of only 1 lb. suspended from the other end of the rope, after passing over a fixed pulley. Hence the weight, or the power, which is the same thing, applied to the simples to pull them down, must be somewhat more than double the sum of all the weights, attached to that part of the harness which is to be raised. See Mechanics.

"But in the case of the patent loom, the harness is raised perpendicularly by the comb; consequently, no more power is required than will overcome the sum of the weights to be raised; and if the lever, at the end of which the comb is fixed, be divided into three equal parts, and the centres, or pivots, placed at the distance of one of these parts from the comb, the power will be again doubled.

From these calculations we may deduce, that the power required to raise the harness of the patent loom, will be only about one-fourth of that required for the other.

But in every species of complicated mechanism, many deficiencies and objections, which may not be obvious to the eye of a transient spectator, frequently become apparent upon practical experience. For this reason, I was at pains to collect from those who were daily employed in working them, their opinions of the comparative merits of the two plans.

When the range of pattern was not very great, I found both the general opinion and practice, which is still more conclusive, decidedly in favour of the pa-

tent loom. It was only respecting the very highest mounted looms, that a difference of opinion seemed to exist. I was informed that two looms, of very extensive range, had been lately mounted; the first of 120 designs, upon the old plan; the second, of 120 designs, upon the patent plan. Both looms were allowed to execute their work in a very sufficient manner, but it was stated, that the mounting of the patent loom, although last set to work, was already much decayed, whilst that of the other, which had produced more cloth, was impaired in no perceptible degree.

Should this prove to be generally the case, it will form a just ground of hesitation, in preferring the new to the old plan, in looms of this description. The mounting of an extensive draw loom, is a work necessarily involving much time, labour, and expense, and the loom must therefore, be employed for a very considerable portion of time, before it will indemnify the proprietor. But it may be possible, admitting the fact to be as stated, which I have no reason to doubt, that the difference of the mounting of these two looms. in point of durability, might be produced by some incidental or contingent circumstances in their construction, independent of the general principle. The cordage of the one might be inferior to that of the other, either in the quality of the stuff, in the spinning, or in both. Some part of the machinery might have been imperfect in the workmanship, and caused unnecessary friction; the mounting might have deviated a little from an equal degree of tension, or from the true level, which must produce more strain on one part than another. Whether any of these causes did operate in this case, I had no means of ascertaining; but, in forming opinions respecting complicated and expensive machines, too much caution cannot be used, in investigating, not only the direct principles of construction, but all the minute and collateral circumstances which may affect their operations. Want of attention to this, has been more injurious to the improvement and extension of practical mechanism, than any circumstance which has come to my knowledge upon that subject. Therefore, without offering any decided opinion upon the fact stated, it may be sufficient to remark, that speculatively and abstractedly considered, the patent loom, particularly the harness part of it, appears to possess some advantage over the other, even in point of durability. The tail, instead of being conducted over pullies to one side, rises perpendicularly to the roof; consequently, the cords deviate much less from a straight line, and the decay which must be produced, both by the friction of pullies, and the deflection of the cords, is, almost entirely avoided. It is, however, to be allowed, that some friction will be produced by pulling the cords betwixt the teeth of the comb, and afterwards, by raising the harness, and that, in the former of these motions, the friction is almost at right angles to the staple of the hemp, or lint, which is a very unfavourable direction.

In these comparisons of the old and patent draw looms, I have endeavoured impartially, to state both the opinions which I had collected, and the remarks which occurred to myself. Probably, some time may still elapse, before the superiority of either will be universally admitted, even by those who, from their practical experience, have the best opportunities of forming an accurate judgment upon the subject.

But, in whatever way a draw loom is mounted, too much attention cannot be paid, both to the quality of the materials and accuracy of the workmanship. This, indeed, is a general rule, and will be found to apply to every description of machinery. No plan of economy can be more ruinous in its effects, than that of constructing any piece of mechanism of insufficient materials, and inaccurate workmanship, for the sake of a small reduction of the first expense. The mounting of an extensive draw loom will occupy a man, for at least four months. Let us then suppose, that the weaver who works this loom, besides paying the person who draws the harness, if he employs one, can earn 1*s.* per day, more than he could if weaving plain cloth. In this case, it will require 288 working days of constant industry, before the price of labour in mounting is repaid, exclusive of the whole expense of the materials. It is plain, that whether a weaver mounts a loom for himself, or employs another to do it for him, the case will be precisely the same, for in both instances the price is estimated by the labour. In the first instance, labour is given; in the second, money: and, by the supposition, the value is the same. But, to make the calculation simple, let us suppose that an operative weaver mounts the draw loom which he is afterwards to work. By the suppositions which we have made, he will expend 96 working days, in the mounting, before he begins to weave, and 288 working days in weaving, before he recovers common wages for the time which he has expended. These, taken

together, amount to 384 working days, to which adding the intervening Sundays, (without any allowance for holidays, sickness, or other causes of impediment,) he will at the end of one year and 83 days, or nearly 15 months, be merely paid for his labour. Now let us again suppose that the money expended or materials of the best quality, in mounting a draw loom, amounts to 10*l.* and, that those of inferior quality, might be purchased for 6*l.* Let us suppose also, that these two mountings will last in proportion to their prices, which, in practice, is never the case, for the vulgar adage, "the best is always the best penny-worth," will here be found invariably true. In this case, the former will last ten months for every s x that the latter will. Let us then suppos , that the very worst mounting will last for two years, and the best for three years and four months; the calculation will then be

For the Worst.

For labour, as before - -	*L* 14	8
For materials - - -	6	0
	20	8

Return.

1*s* per day for 626 working days	31	6
The profit therefore, to the weaver, will be - - - - -	10	18
excluding interest.		

For the Best.

For labour - - -	*L.* 14	8
For materials . - -	10	0
	24	8

Return.

1*s* per day for 1043 working days	52	3
Or of profit, excluding interest	28	15

In both cases, it is supposed, that each kind of material has been laid in at the fair market price, and that no imposition has been practised on the buyer.

The grounds upon which these calculations are made, have been taken entirely at random, to illustrate and prove the position advanced. Whether the price of wages, the cost of materials, or the durability of the apparatus, be taken high or low, the inference will be nearly the same. In every state of the price of labour, if good materials only repay a weaver, bad will ruin him; and, if bad materials yield him a profit, good ones would yield him much more. Simple as this principle is, and easily demonstrable, there are few from which there are more deviations in common practice. I have known incalculable loss, in many instances, arise from this deviation, and have, therefore, entered more into the consideration of it, than I should have done, were it more generally understood, and practised in the affairs of common life.

We now proceed to consider the application of the draw loom to the weaving double cloth, and to explain the difference which exists between the damask and

Carpet Draw Loom.

Carpets, being generally composed of coarse and bulky materials, there are, of course, much fewer splits. or threads, in the warp, than in that of a damask; and, consequently, the drawing apparatus is much less extensive. The common run of carpets do not exceed 10 porters of warp, 4 threads in the split, in the breadth of 37 inches, which is equal to a 500, wrought two in the split or 1000 threads. The harness and mails of the carpet draw loom, are perfectly similar to those of the damask, excepting that they are larger and coarser. In drawing a carpet through the harness, only one thread passes through each mail, and one thread of each of the two warps is drawn alternately. The draught, through the harness, proceeds in regular succession, as in the damask, and two threads of each warp pass between the same splits of the reed, which is, generally, of steel. It is found in general, unnecessary to use simples in the carpet draw loom; the lashes, therefore, are attached directly to the cords of the tail, from which they hang down perpendicularly at one side of the loom. To the lower end of each set of lashes is tied a cord, and to the other end of this cord, is suspended a small handle, or bob.

Fig. 6. Plate 21. is a transverse elevation of part of a carpet draw loom, showing how the lashes and bobs are attached to the tail. A is the box or frame of pullies, B the tail, C the lashes, G the board through which the cords pass, H the bobs. The bobs are suspended in two rows, as represented in Fig 7. which is a section of the board G, showing two of the bobs. Of these bobs, one lifts that portion of the black warp which is to be uppermost; the other lifts the white in the same manner, supposing still that these are the two colours of which the carpet is composed. The four front leaves open the sheds, two being set apart for the black warp, and two for the white.

The front leaves of the carpet draw loom are exactly similar to those of the diaper, the eyes being of a length, rather more than the depth of the shed, so that they may not interrupt the harness in rising. In some looms, the whole is mounted as a harness, and the treddles are con-

nected with certain of the tail cords. Upon inquiring of persons, who had been long in the habit of working both, I could not ascertain that any decided preference was to be given to either plan Both are found to do very well, and both are generally used in different manufactories.

Let us now suppose, that Fig. 4. Plate 24. is to be wrought as a carpet, and that the figure is black upon a white ground. In this case, when a white shot is thrown across, the figure must be raised, and the ground sunk; and when a black shot is inserted, the ground is to be raised, and the figure sunk. For the first, the instructions, in reading on, will be the same with those given for damask, and for the second, directly the reverse. As the shots of weft are thrown in alternately, the harness must be changed at every shot, and for this reason the bobs are placed in pairs, as represented by Fig. 7. Plate 21 The instructions, therefore, will be

1st. White shot, pass 30 and take 2.
Black shot, take 30, pass 2, take 13.

and so on, whatever is passed in the one case, being taken in the other.

Different plans have been tried in carpet weaving, as well as damask, to supersede the use of the draw boy. Hitherto, none of them have come into very general practice, although there seems no reason to doubt that some saving may be effected in this way. Carpet weaving, however, does not possess the same facilities for this as damask, for in the former, as the harness must be changed at every shot, if the time of doing so should impede the weaver, even very little, more will be lost than an equivalent for the wages of a draw boy. Besides this, as the weaver must shift his shuttle at every shot, he is sufficiently occupied without being obliged to change his harness.

Carpets are seldom warped upon mills, for the yarn being very coarse, the warp is found not to be sufficiently stretched. A square frame of wood is, therefore, commonly used, with pins at certain distances, over which the warp is stretched by the warper, in a manner similar to the old practice. As the warps of carpets do not contain many threads, this practice is considered sufficiently expeditious

When carpets consist of more than two colours, they are woven exactly as checks, and merely require additional shuttles to insert the weft, the same as the warp. There is no difference in the process It is not yet customary to use the fly shuttle in carpet weaving, and when the webs are too broad for one man to stretch, two are employed, one at each side of the loom.

Many kinds of carpeting for rugs, passage, and stair cloths, &c. are also woven in the plain loom.

Carpets are also manufactured with flushing like velvet, which is afterwards cut. When this is the case, wires are introduced into the shed, to form the length of the flushing. In each of these wires is a groove, and when the weft has been thrown across, a sharp pointed knife is passed along the groove, which serves as a guide for it. The wire is thus relieved, and the cut warp forms the flushing. These may be either wrought plain, or in figures raised by the harness. This manufacture is chiefly carried on at Kidderminster, and has hardly been introduced at all in Scotland. From the name, it appears to have been originally imported from Turkey. Very elegant carpets are also manufactured in France.

Quiltings are also double cloths, and are manufactured exactly upon the same principle as carpets. The two webs are generally of the same colour. This manufacture is also derived from the French, and was chiefly carried on in the neighbourhood of Marseilles. Those made in England, are generally of cotton.

Weaving by Mechanical Power.

I now come to consider the various plans, which have been lately adopted for the purpose of working the weaving loom, by the application of power. Many experiments, upon a small scale, have been made for a considerable number of years past, and looms, upon various plans, constructed. The first attempt to establish a regular manufactory of this description, in Scotland, was, I believe, that of Mr. Robert Miller, at Milton Printfield, Dumbartonshire, which is still prosecuted.—These looms, for which a patent was obtained, receive their motion from treddles, moved by those excentric wheels, which are known among mechanics by the name of wipers.

Another loom, the origin of which I believe to be English, but which has lately been introduced in Scotland to a considerable extent, is the crank loom. The last invented by Mr. Johnson, and brought into practice by Mr. Robert Shirreff, for which also a patent has been granted, is the vertical loom.

In these looms, different modes of construction have been adopted, without any materal deviation from the same general principle. The plan of weaving by power, has been so recently introduced, and hitherto confined to so few hands, that it is

natural to suppose, that many improvements still remain to be made, and that much difference of opinion, respecting the relative merits of the different plans does, and will, for a considerable time, exist. I shall, for these reasons, confine my observations and descriptions to the principal moving parts of each, leaving the connections, and framing of the machines, to the judgment and discretion of those, who may apply them to practice.

With the exception of the motion for winding up the cloth, and unwinding the warp, which is rotary on the axes of the beams, all the motions of the loom are alternate, or reciprocating. The two methods, most common among mechanics, of producing these motions, are cranks and wipers, or excentric wheels.

The reciprocating motion derived from the evolution of a crank on its own axis, is not uniform, but accelerated at one time, and retarded at another. By means of wipers, the motion may be made uniform, accelerated, or retarded, at any part of the revolution, according to the effect which the engineer wishes to produce.— In many machines, this property gives the wiper a very decided advantage over the crank: but in the weaving loom, the retardation of the crank, so far from being disadvantageous, is of considerable service.

In Plate 22, 23, and 24, will be found representations of the chief working parts of the different power looms; and as the vertical loom is the one most recently invented, I have given a profile, and transverse elevation of it, from drawings, for which I am indebted to Mr. Shirreff.

Wiper Loom.

Plate 22, Fig. 1. *Weaving*, is a representation of the way of moving the heddles in this loom, so as to open the sheds. This figure is a profile elevated section of the heddles L, Fig. 9, connected with the treddles R, Fig. 1, much in the same way as in a common loom. In some power looms, the cords above the heddles, pass over pullies, as in the figure; in others, Jacks are used, as in the common loom. The motion is given to this loom, by a horizontal cross shaft, upon which are a number of wipers. A section of this shaft, with the double wiper, which sinks the two treddles alternately, is represented at S.

These wipers may be constructed for any range of motion, in the following manner. Describe a circle of a convenient diameter on the piece of wood, or other substance, which is to form the wiper. Having considered the range which the wiper is to communicate to the treddle, draw a diameter line through the circle, and upon this line, set off the length of the proposed range on the outside of the circle. At this point, describe a second circle concentric with the first, and divide the circumference into a great number of equal parts. From the centre draw a radius to each of these divisions, and the wiper will be ready for setting off. If a uniform reciprocating motion is wanted, during the whole revolution of the wiper, it is only necessary to divide the space between the inner and outer circle, into as many equal parts as half the number of radii. Set off one of these parts on the first radius line, two on the second, three on the third, and so on, until the whole are set off, when the semi-circumference of the wiper will be worked off; and the same operation reversed, will give the other or returning side. This forms exactly the common heart traverse. In the figure, a few radii are drawn upon S, to show the principle; but it will appear that each of these two wipers is constructed on half the circle, so that each may operate alternately on its respective treddle, when both sheds will be opened by one revolution of the shaft. As it is necessary that the shed should remain open, while the shuttle is passing through, all the range must be set off, some time before the wiper arrives at the centre, and the extremity left circular, to suspend the motion for the time required. This is the case with the two wipers at S.

Fig. 2. is a profile elevation of the apparatus, for moving the lay. E is the lay vibrating on its centres above, as in the common loom. The lay is pulled back by the operation of the wipers S, upon the treddle R, by means of the connection represented in the figure. After the shuttle has passed through the shed, the lay is pulled forward by a weight attached to a cord or belt, passing over a pully, as represented. These wipers are also constructed on semi-circles, that the lay may operate twice in one revolution, as well as the heddles. Both wipers, however, operate upon the same treddle, as they are only intended to repeat the same motion, while those which move the heddles must reverse the shed. There is an apparatus of this kind at each side of the loom, to keep the lay steady. The wipers for this motion are upon the same shaft, with those for the heddles. In some power looms, the swords of the lay are reversed, and move in centres below. There are different ways for driving the shuttle. In some, the driver cords are attached to the point of a lever, with two cross tails,

as represented by Fig. 3. This lever, being placed perpendicularly under the warp, with a flat side parallel to the horizontal shaft, and moving freely on its centre, the cross tails are alternately struck by two pieces of iron, fixed to the shaft, as represented at U, in Fig. 7. and, by moving the lever, drive the shuttle across the web. In other looms, two treddles are used, which are moved alternately, by wipers on the shaft, and produce the same effect. Various means are also used for winding up the cloth, of which some notice will be taken, when we come to consider the vertical loom. In the mean time, we proceed to the

Crank Loom.

In this loom no treddles are necessary, for the motion is communicated directly by the cranks. Fig. 4. is a profile of the heddles, and section of the heddle crank shaft. The shape of the cranks will appear by Fig. 5. where a small portion of the shaft is represented in a transverse direction. Fig. 6 is a profile of the lay, and section of the lay crank shaft. Fig. 7. is a transverse view of the shaft, to show the way of disposing the cranks. It will be obvious, that in this loom two horizontal shafts are necessary, for only one stroke of the lay, can be effected by a whole revolution of the lay shaft, whereas in the wiper loom, the double wiper gives two. These shafts are placed parallel to each other, and on the same level, the heddle cranks being perpendicularly under the heddles,and the lay cranks behind. As it is necessary that the lay shaft should revolve twice, while the heddle shaft revolves once, the latter takes its motion from the former, by a spur wheel and pinion, as represented by Fig. 8. The wheel containing double the number of teeth of the pinion, is fixed on the heddle shaft, the pinion on the lay shaft. The pully, which receives the motion from the power, is also on the lay shaft. The swords of the lay are lengthened below the boxes, to bring the connecting rods level with the shaft, and these connecting rods, in both motions, are usually of iron. The shuttle motion is effected by either of the two plans formerly described. We now come to the last invention, the

Vertical Loom.

Plates 23, and 24, are elevations of two of these looms, constructed at opposite sides of the same frame, and will convey a tolerably correct idea of their framing appearance. Plate 24, Fig. 1. is a transverse elevation of one end. The figures, 9 to 13, plate 22, inclusive, are the several working parts. The whole reciprocating motions of the vertical loom, are also effected by cranks, and these cranks are upon two shafts.

A is a balance wheel on the lay crank shaft, one side of which is so much heavier than the other, as to counterpoise the weight of the lay and swords, and make them ascend and descend with equal ease. The swords rise and sink between sheers, or guides, to keep them steady.

B is the pully which takes the motion from the power, and which is also on the lay shaft.

C is the lay shaft, with a crank at either end, similar to those of the crank loom.

D is a wheel on the heddle shaft, receiving motion from a pinion of half the number of teeth on the lay shaft, as in the crank loom.

E is the lay and boxes, with the reed placed horizontally, and on which the shuttle runs.

F is the yarn beam, from which the warp ascends perpendicularly through the mounting.

G is the cloth beam above, for receiving the cloth when woven.

H the wheels by which the cloth is wound up.

I is the lever and fork, for engaging or disengaging the machine at pleasure.

K is a catch, by which the loom will be instantly stopped, if the shuttle should remain in the shed. All the power looms have contrivances of this kind, which will be more particularly noticed afterwards.

The nature and construction of each particular motion will appear very plainly, by inspecting the supplementary figures.

Fig. 9, Plate 22, contains a profile of the horizontal heddles, and the apparatus for moving them.

At L are the heddles, placed horizontally, and guided by belts, passing over pullies before and behind. To one of these belts is attached one end of the bended lever M, moving freely on its centre, and the other end of which is connected with the crank N. The shape of this shaft and crank, will be plainly seen in Fig. 10. Besides the crank for the heddles, upon this shaft is a projecting stud P, operating like a crank for giving motion to the shuttle.

Fig. 11. is a profile elevation of the apparatus by which the shuttle motion is communicated. O is a sliding bar which moves freely in two bushes backward and

forward. Upon the edge of this slider, is a rack which moves a pinion Q, fixed upon an upright shaft, on the upper part of which is a cross lever, to which are attached two leather thongs, which are also connected with the drivers. The stud P, the end of which appears here, like a round dot, moving round in a hollow elliptical piece, forming part of the slider, alternately moves it rapidly, backwards and forwards, by means of the catches above and below. This motion drives the cross lever upon the top of the upright shaft, to the right and left alternately, by means of the pinion Q, and thus the motion is communicated to the drivers.

Fig. 12. is a ground plan of the rack and pinion.

Fig. 13. is an outline of the plan for winding up the cloth. On the axis of the cloth beam is fixed a wheel, on the outside of which is a ratchet wheel, loose upon the axis. This ratche , one tooth of which is represented, is moved by a catch, jointed to the end of a spring connected with a lever; the other end of this lever is connected with the lay This spring may be slackened, or stiffened at pleasure. Every time the lay rises, the spring and lever are pulled down, to move the racket one tooth; but the spring is made sufficiently slack, to yield without moving the racket, unless assisted by the stroke of the reed, upon the fell of the cloth. Consequently, if the weft breaks, no winding-up motion is produced. This is very necessary; for, were the loom to go a shot or two without weft, and the cloth to be wound up, it must either be let back, or a large unwefted interval would be produced. Upon the ratchet is fixed a pinion, which moves a wheel turning loosely upon a stud. Another pinion, fixed to this wheel, gives the motion to the fast wheel, on the axis of the cloth beam, and consequently to the beams. The relative numbers of these wheels and pinions, must depend on the quantity of weft in a given space, and they must be fitted on, so as to be easily altered at pleasure.

In all the different experiments upon weaving by power, hitherto made, it has been found advantageous to confine the shuttle when lodged in either box, to prevent it from recoiling. This has been effected by a circular piece of wood, pressed through one of the edges of the box by a slight spring, which yields to the pressure of the shuttle when entering, and by its friction, prevents the recoil. It is also material to disengage the loom from the power instantly, if the shuttle should stop in the shed; for if driven up by the lay, much damage will be the probable consequence. This disengaging motion, is taken from these springs, which are connected by bended levers, and a wire across the lay, so that either will operate. In the vertical loom, the disengaging lever I, is strongly pressed by a spring, to force out the driving pully, whenever the catch above is lifted. To the spring for securing the shuttle, an upright piece of iron K, moving in a joint is attached. When the spring is pressed back by the shuttle, the upper part of this is thrown forward, clear of a notch in an upright slide, attached to the disengaging catch; but if one spring is not pressed, K not being thrown forward, will strike the notch, and instantly disengage the machine. The contrivances for disengaging the other looms, are exactly upon the same principle, a little differently modified, to suit the construction of the looms.

When the vertical loom is to work yarn which requires dressing, an iron roller is placed where the yarn beam is represented, aud the beam itself in a small additional frame, parallel to, and on a level with the roller, so that the part to be dressed is in a horizontal position, as in a common loom. Every power loom is generally furnished with a circular fan, such as formerly described, placed under the warp, and which is occasionally set in motion, to dry the yarn after being dressed. Two pair of temples are generally used in power weaving.

It is not easy to decide, justly upon the comparative merits of these looms, and upon this subject a considerable difference of opinion still prevails The wipers are, without doubt, susceptible of a modification of the motion, to suit different fabrics, in a much greater degree than the cranks; but in the coarse fabrics, hitherto woven by power, the crank motions are found sufficiently correct. The mode of striking up the lay, by means of a weight, is found productive of one very considerable inconvenience. The force of the lay has a tendency to slacken, and, consequently, to spread the warp, and when the shed closes in this state, the threads are apt to obstruct each other, and occasion breaking. A very simple and ingenious apparatus, has lately been added to the vertical loom, to obviate this disadvantage, which also attends the crank loom, although not to an equal degree. This is merely a flat board, the edge of which is parallel to the warp, and which moves on centres. By means of two bended levers, connected by cords, or thongs, to the lay, this board presses the warp when the shed closes, and re-

cedes from it when the shed is opened.—Thus the warp is kept uniformly tight. The same contrivance might easily be applied to either of the other looms.

The vertical loom certainly appears to possess some decided advantages over the others.

1stly, It occupies a much smaller space of room, and consequently, in a large manufactory, a considerable saving might be effected, both in the expense of building, and in that of shafts or other mill-work.

2dly, From the shuttle running upon the reed, a larger pirn may be used, without any risk of injuring the warp by friction.

3dly, When it is necessary to dress the warp, which, in power weaving, is usually done without stopping the loom, it presents the following very important advantage. The operator, while dressing, remains exactly in the same situation as when attending the working, and can, therefore, see in a moment, any thing which may go wrong; whilst in the other looms, the person while attending the working, must be in front, and when dressing, behind, where it is very difficult to see any obstruction, which may happen before the reed.

Practical experience has proven, the danger and inconvenience of working a loom beyond a proper rate of velocity, as highly injurious to the manual op ration, and I am fully convinced, it must be equally, if not more prejudicial, in weaving by power. It has been common to drive power looms, at the rate of 80 or 90 shots per minute, and attempts have even been made, to accelerate this velocity much beyond 100 shots. Mechanics know that even rotatory motion, when urged beyond a moderate speed, always fails in producing the effect expected. This has been sufficiently proved in spinning, where almost all the motions are rotatory. In weaving, where there are no less than three reciprocating motions, the effect must be still more injurious, especially in the lay and heddle motions. The shuttle, indeed, may be driven with considerable swiftness, for no injury can arise from this, unless the shuttle is thrown out of the box, or the weft too much strained and frequently broken. Suppose, a 1000 4-4th shawl cloth, with 1200 weft, to be woven at the rate of 80 shots per minute. This will give a yard in 30 minutes, or 24 yards per day of 12 working hours, if no stop were to take place. I cannot state with certainty, what has been the greatest quantity of cloth of this description, produced by power looms. The average quantity on the vertical loom, I have been informed, is about 15 yards, so that, if the loom works at the velocity quoted, more than one-third of the time must be lost by stopping. Besides, I do not think that goods of this description have, in general, so much weft, as I have taken in the calculation. Upon the whole, I should suppose 70 or 80 shots to be the *maximum* of velocity, at which it is prudent to drive a power loom, even with the coarsest and strongest materials; and if these looms are applied to weave finer and lighter fabrics, I suspect even this velocity must be considerably diminished.

The last plans of economy in weaving, which it will be necessary to discuss, are those which relate to the insertion of the weft. The process of winding the weft upon the pirn, whether from the hank or the cop, is tedious, and consequently expensive. Two means of reducing this expense, have been devised. The first of these is, by placing the cop itself in the shuttle upon a skewer,by which the whole expense of winding is saved. As the cops, however, are generally too large for an ordinary shuttle, it has been usual to compress them. This is effected by means of two hollow inverted cones, generally of brass, with a hole through the vertex of each, to admit the skewer, the two cones are pressed together by means of a lever or screw The cop, being between the cones, is thus compressed to a much smaller space, than it originally occupied. The compression is most effectual, when the cop has been boiled, but this can only be done when the weft is to be inserted in a wet state.

Machines have also been constructed for winding a number of pirns at the same time. The principle is entirely the same with that of the machine, for winding the warp bobbins The only difference is in the shape of the traverse, which must be constructed to wind the yarn in the form of a cone, instead of being flat or barrel shaped. Those which I have seen are turned by the hand, which I cannot think is proper, for the same reason which I stated before; namely, that in all these machines, the person who attends ought to have both hands free, and should be at liberty, to shift from one part of the machine to another, to remove obstructions, and knot broken threads. I do not think that these machines are, as yet, very generally employed, and, perhaps, they have not yet reached such a state of improvement, as to render the use of them an object of much importance, in point of economy.

Having thus given a concise treatise on some of the most important parts in weaving, we are obliged for want of room, to conclude, referring the reader who is desirous of acquainting himself more fully on this subject to a book entitled "Practical and Descriptive Essays on the Art of Weaving, by John Duncan," where he will find a full and complete treatise on every part of this ingenious and interesting art.

WEDGE. See MECHANICS.

WEED-ASHES, are a kind of wood ashes not lixivated, but repeatedly wetted with the lye of wood-ashes, and calcined to a degree, so as to vitrify; on this accouut it is difficult to extract their salt.

WELD, is a plant cultivated in Kent, Herefordshire, and many other parts of this kingdom. It is likewise very common in the environs of Paris, in most of the French provinces, and in a great part of the rest of Europe It pushes out long narrow leaves, of a lively green. From the midst of these leaves the stalk rises to the height of three or four feet, frequently branchy, and furnished with leaves, narrow, like the radical ones, but shorter as they approach the flowers, which are disposed in long spikes. The whole of the plant is used for dyeing yellow; though some assert that the seeds only afford the colouring matter.

Two sorts of weld are distinguished: the bastard or wild, which grows naturally in the fields; and the cultivated, the stalks of which are smaller, and not so high. For dyeing, the latter is preferred, as abounding more in colouring matter. The more slender the stalk, the more it is valued.

When the weld is ripe, it is pulled, dried and made into bundles, in which state it is used.

When the decoction of weld is very strong, it has a yellow colour inclining to brown. If it be greatly diluted with water, its yellow, which is more or less pale, inclines a little to green.

If a little alkali be added to this decoction, its colour grows deeper, and after a certain time, a little ash-coloured precipitate falls down, which is not soluble in alkalies.

Acids in general render its colour paler, and occasion a little precipitate, which will dissolve in alkalis, giving them a yellow colour inclining to brown.

Alum forms with it a yellowish precipitate, and the liquor retains a fine lemon-colour. If a solution of alkali be poured into this liquor, a whitish yellow precipitate, soluble in alkalies, is thrown down, but the liquor still remains coloured.

Solution of common salt, or of sal ammoniac, renders the liquor turbid, and its colour at first a little deeper; by degrees a deep yellow precipitate forms, and the supernatant liquor retains a pale yellow colour, a little inclining to green.

Solution of tin produces a copious bright yellow precipitate. The liquor remains a long time turbid, but slightly coloured.

Sulphate of iron produces a plentiful dark grey precipitate, and the supernatant liquor is brownish.

Sulphate of copper occasions a brownish green precipitate, and the liquor preserves a pale green colour.

The yellow communicated to wool by weld, has little permanency, if the wool be not previously prepared by some mordant. For this purpose alum and tartar are used, by means of which this plant gives a very pure yellow, which has the advantage of being permanent.

For the boiling, which is conducted in the common way, Hellot directs four ounces of alum to every pound of wool, and only one ounce of tartar: many dyers however, use half as much tartar as alum. Tartar renders the colour paler, but more lively.

For the welding, that is, for the dyeing with weld, the plant is boiled in a fresh bath, enclosing it in a bag of thin linen, and keeping it from rising to the top by means of a heavy wooden cross. Some dyers boil it till it sinks to the bottom of the copper, and then let a cross down upon it; others, when it is boiled, take it out with a rake, and throw it away.

Hellot directs five or six pounds of weld for every pound of cloth; but dyers seldom use so much, contenting themselves with three or four pounds, or even much less. Many indeed add to the weld a little quick-lime and ashes, which favour the extraction of the colouring matter, and heighten its colour, but at the same time render it liable to be changed by the action of acids. The quantity of weld, however, ought to be proportionate to the depth of the shade to be obtained.

Lighter and brighter shades may be obtained by dyeing after deeper ones, adding water at each dipping, and keeping the bath boiling; but light shades procured in this way are not so lively as when fresh baths are used, proportioning the quantity of weld to the depth of the shade.

Common salt added to the weld-bath renders its colour richer and deeper:

sulphate of lime, or gypsum, also deepens it; but alum renders it paler and more lively, and tartar still paler. Sulphate of iron makes it incline to brown.

The shades obtained from weld may be modified, by such additions, by the proportion of the weld, by the length of the operation, and by the mordants employed in preparing the stuff. Thus, Scheffer says, that by boiling the wool two hours with a fourth its weight of solution of tin, and the same of tartar, washing it and boiling it fifteen minutes with an equal weight of weld, it will take a fine yellow, which, however, will not penetrate its internal texture. Mr. Poerner also directs the cloth to be prepared as for dyeing scarlet. By these means greater brightness and permanency are given to the colour, which *cæteris paribus*, is at the same time lighter.

The colour may be modified also by passing the cloth, when it comes out of the dye, through another bath. Thus, to produce a golden yellow, the cloth, when it comes out of the welding, may be passed through a slight madder-bath; and for a tawny, through a bath made with a little soot.

To dye silk plain yellow, in general no other ingredient than weld is used. The silk ought to be scoured in the proportion of twenty pounds of soap to the hundred, and afterwards alumed and refreshed, that is, washed after the aluming.

A bath is prepared with two pounds of weld for each pound of silk, which, after a quarter of an hour's boiling, is to be passed through a sieve or cloth into a vat. When it is of such a temperature as the hand can bear, the silk is put in, and turned till the colour becomes uniform. During this operation the weld is boiled a second time in fresh water; about half of the first bath is taken out, and its place supplied by a fresh decoction. This fresh bath may be used a little hotter than the former; too great a degree of heat, however, must be avoided, that no part of the colour already fixed may be dissolved; it is to be turned as before, and in the mean time a quantity of the ashes of wine lees is to be dissolved in a part of the second decoction; the silk is to be taken out of the bath, that more or less of this solution may be put in, according to the shade required. After it has been turned a few times, a hank is wrung with the pin, that it may be seen whether the colour be sufficiently full, and have the proper gold cast; if it should not, a little more of the alkaline solution is added, the effect of which is to give the colour a gold cast, and to render it deeper. In this way the process is to be continued, until the silk has attained the desired shade: the alkaline solution may also be added along with the second decoction of the weld, always taking care, that the bath is not too hot.

If we wish to produce yellows, with more of a gold or jonquile colour, a quantity of anotta, proportioned to the shade required, must be added to the bath along with the alkali.

For the light shades of yellow, such as pale lemon, or canary-bird colour, the silk ought to be scoured as for blue, because the shades are more beautiful and transparent in proportion, as the ground on which they are laid are whiter. The strength of the bath is proportioned to the shade we wish to obtain; and if we intend, that the yellow should have a tinge inclining to green, more or less of the indigo vat is added, if the silk has not been azured. To prevent the shades from being too deep, the silk may be more slightly alumed than usual.

Scheffer directs, that the silk should be soaked twenty-four hours in a solution of tin, made with four parts of nitric acid, one of common salt, and one of tin, and saturated with tartar; that it should be washed, and boiled half an hour with an equal quantity of weld flowers. He says, that a fine straw-colour is thus obtained, which possesses the advantage of resisting the action of acids. By following this process, very little tin can remain in the solution, because the acid of tartar precipitates it.

In dyeing cotton yellow, we begin by scouring it in a bath prepared with the ley of the ashes of green wood; it is then washed, dried, and alumed with one-fourth of its weight of alum; after twenty-four hours it is taken out of the aluming, and dried without being washed. A weld bath is then prepared, with the proportion of a pound and a quarter of weld for each pound of cotton; in this the cotton is dyed, by being turned and wrought in it until it has acquired a proper shade; it is taken out of this bath to be soaked for an hour and a half, in a solution of sulphate of copper, in the proportion of one-fourth of the weight of the cotton; it is then thrown, without being washed, into a boiling solution of white soap, made with the same proportions. After being well stirred, it is boiled in it for nearly an hour, then well washed and dried.

A water-colour, called weld-yellow, is much used by paper-hanging manufacturers. This is the colouring matter of weld precipitated with an earthy base. The following is given in the Philosophical

Magazine:—Into a copper vessel put four pounds of fine washed whitning, and as much soft water, and boil them together, stirring them with a deal stick, till the whole forms a smooth mixture; then add gradually twelve ounces of powdered alum, still stirring, till the effervescence ceases, and the whole is well mixed. Into another copper put any quantity of weld, with the roots uppermost, pour in soft water, enough to cover every part containing seed; let it boil, but not more than a quarter of an hour; take out the weld and set it to drain; and pass the whole through flannel. To the hot mixture of earth and water, add as much of this decoction as will produce a good colour, keep it on the fire till it boils, and then pour it out into a deal or earthen vessel. The next day the liquor may be decanted, and the colour dried on chalk.

WELDING. Steel being considerably more expensive than iron, it is customary in making the larger and coarser kinds of cutting instruments, to form only the edge of steel. The two bars of iron and steel are first welded together, and afterwards forged into the requisite shape, in the usual manner. Highly carbonized steel, is however incapable of being thus united to iron, because the same temperature at which iron welds freely, is that at which this kind of steel enters into fusion, and therefore the first stroke of the hammer, will entirely shatter the steel, and disperse it about in small fragments. This however is a difficulty which is well worth while taking some pains to overcome, as the efficacy and durability of instruments thus composed, materially depends upon the goodness of the steel. The most effectual way hitherto discovered of uniting together, iron and highly carbonized steel, is that published by Sir Thomas Frankland. The iron is to be raised to a welding heat, in one forge, and the steel is to be made as hot as it can bear, without becoming very brittle, in another; both pieces are then to be quickly brought to the anvil, and made to adhere together by gentle hammering.

No less than three experiments failed to weld Huntsman's cast steel to iron, agreeably to Sir Thomas Franklan's process, conducted in the presence of Dr. Mease, and at his request, by the late Mr. 'Schively, cutler, of Philadelphia, and an expert workman. The degrees of heat prescribed for both iron and steel, were scrupulously attended to.

This secret process was reserved for the United States. Mr. Pettibone, now of Philadelphia, welds cast steel to iron with ease and expedition. He even plates clothier's shears with steel, or plates iron of any length or breadth; or faces anvils, hammers or sledges. See Pettibone's list of patents in his "Economy of Fuel." See also IRON.

WHALE OIL. See TRAIN OIL.

WHEAT, starch from. See STARCH.

WHEEL WORK. See MECHANICS.

WHEEL CARRIAGE. See WAGGON.

WHEEL and AXLE. See MECHANICS.

WHETSTONE, is a kind of sand stone, generally of a dusky yellow colour, and is employed for sharpening knives, and other edge tools. Quarries of whetstone are found in several places of the United States; and some of an excellent quality. The red sand stone, owing to the scarcity of the other description, have been made into grind stones, but we are sorry to say that the stone is too soft and friable, for the purpose.

WHETSLATE, called also novaculite and Turkey stone, we have mentioned under the head of Turkey stone, is found in abundance of an excellent quality, in the United States.

WHEY. See MILK.

WHISKEY. See SPIRITS, DISTILLED.

WHITE. See COLOUR MAKING.

WHITE COPPER. See COPPER.

WHITE LEAD See LEAD.

WHITE WAX. See WAX.

WHITING, is chalk pulverized and washed, by which means it is freed from whatever gritty particles it may contain, and afterwards dried. Whiting is used largely for polishing metals and the like.

WHITE WASH, lime slacked in, and mixed with water. White may be changed into yellow wash, very expeditiously, by mixing with it a solution of copperas, and into green wash, by mixing it in the same manner with blue vitriol. Either wash before it is used for washing the ceilings of rooms &c. may be rendered more durable by mixing with it a solution of glue. The lime which is first caustic, becomes hard, in consequence of the evaporation of the water, and the absorption of carbonic acid.

WHITE WASH WITH MILK. See COLOUR MAKING.

WILLOW. We mention this wood in this place, principally on account of its use when charred, in the manufacture of gun powder. Some observations on this subject may be found in the article GUN POWDER.

Willow is a genus of trees comprising 42 species, a great number of which is indiginous, and many of which are useful

in making handles, cutting and whetting boards for shoemakers; the bark of the species *capreata* for tanning, with the alder bark for dyeing linen yarn of a black colour; the shoots of the rose, purple, and red willow for baskets, cradles, and other articles of wicker work; the leaves of the sweet-leafed willow for yellow dye, the plant branches for hampers, the down of the seeds with cotton for the manufacture of stockings, and other articles, &c.

WINCH. See MECHANICS.

WIND. See METEOROLOGY.

WIND MILL. See MECHANICS.

WINE, is an agreeable, spirituous aromatic liquor, prepared by fermenting the juices of sundry vegetable products. The following is a receipt to make an excellent American wine, by Joseph Cooper, Esq. of Gloucester county, New-Jersey.

"I put a quantity of the comb, from which the honey had been drained, into a tub, and added a barrel of cyder, immediately from the press; this mixture was well stirred, and left for one night. It was then strained, before a fermentation took place; and honey was added, until the strength of the liquor was sufficient to bear an egg. It was then put into a barrel; and after the fermentation commenced, the cask was filled every day, for three or four days, that the filth might work out of the bung-hole. When the fermentation moderated, I put the bung in loosely, lest stopping it tight might cause the cask to burst. At the end of five or six weeks, the liquor was drawn off into a tub, and the whites of eight eggs, well beat up, with a pint of clean sand, were put into it. I then added a gallon of cyder spirit, and after mixing the whole well together, I returned it into the cask, which was well cleaned, bunged it tight, and placed it in a proper situation for racking off, when fine. In the month of April following, I drew it off into kegs, for use, and found it equal, in my opinion, to almost any foreign wine. In the opinion of many judges, it was superior.

"This success has induced me to repeat the experiment for three years; and I am persuaded, that, by using clean honey, instead of the comb, as above described, such an improvement might be made, as would enable the citizens of the United States to supply themselves with a truly federal and wholesome wine, which would not cost a quarter of a dollar per gallon, were all the ingredients procured at the market price; and would have this peculiar advantage over every other wine, hitherto attempted in this country, that it contains no foreign mixture, but is made from ingredients, produced on our own farms."

Dr. Aigster observes, in the Gleaner (a periodical work published at Pittsburg) that "The culture of the vine has been by no means yet sufficiently tried in the U. S. The attempts, however, made by the American Vineyard Society, near Philadelphia, by the Swiss settlers, on the banks of the Ohio, in Indianna, by the Harmony Society, near Pittsburg, and by Mr. Henderson, on the Juniata, deserve the greatest praise. The grapes of all the vineyards are greatly deficient in the saccharine principle, which is to furnish the alcohol, and consequently the wine made from them, is destitute of body, and contains a superabundance of acid.—The Harmony wine is certainly of all the most palatable, which is not so much owing to the local position of the vineyard, a circumstance in which the Swiss vineyard has by far superior advantages, but to the judicious method, and to the persevering labour, with which this industrious beehive conduct their undertakings. All the vines hitherto cultivated in this country, have been transported from Europe. Would it not be worth while to try, how far culture could succeed in improving our native grapes? Besides the various kinds of grapes which are common on the east side of the Alleghanies, we find on the Ohio and the Mississippi, two particular kinds of vines, the *vitis æstivolis* and the *vitis riparia*. The grape of the latter is said to be very fine, and there is every reason to suppose, that by careful culture, it might be highly improved in its native soil."

We shall now state the method, in which foreign wines are obtained from the fruit of the vine.

When the grapes are sufficiently ripe, they are gathered, and submitted to the action of a press; from which their juice runs into vessels furnished for that purpose. Here it remains for several hours, or for a few days, according to the temperature of the atmosphere. When the fermentation commences, the liquor rises, and a considerable portion of fixed air, or carbonic acid gas, is evolved. At the expiration of some days, the fermentation ceases. When the liquor becomes clear, and cool, it is poured into other casks or vessels, where it undergoes a slight degree of a new fermentation, in consequence of which, it becomes divested of all feculent particles, while its taste and flavour are remarkably improved.

Dr. Thompson observes, that the *must* of grapes, which is the juice, is composed almost entirely of fine ingredients; namely, water, sugar, jelly, gluten, and tartaric acid, partly saturated with potash. The quantity of sugar which grapes fully ripe contain, is considerable; it may be obtained by evaporating *must* to the consistence of syrup, separating the tartar which separates, and then setting the *must* aside. Crystals of sugar gradually form. The component parts of wine, with observations on the subject, are given by the Dr. in the following words:

The properties of wine differ very much from each other, according to the nature of the grapes from which the *must* was extracted, and according to the manner in which the process was conducted. These differences are too well known to require a particular description. But all wines contain less or more of the following ingredients; not to mention water, which constitutes a very great proportion of every wine.

1. *An acid.*—All wines give a red colour, to paper stained with turnsole, and of course contain an acid. Chaptal has ascertained that the acid found in greatest abundance in wine, is the malic, but he found traces also of the citric acid, and it is probable that the wine is never entirely destitute of tartar All wines which have the property of frothing, when poured into a glass, contain also carbonic acid, to which they owe their briskness. This is the case with Champagne. These wines are usually weak; their fermentation proceeds slowly, and they are put up in close vessels before it is over. Hence they retain the last portions of carbonic acid that have been evolved.

2. *Alcohol.*—All wines contain less or more of this principle, to which they are indebted for their strength; but in what particular state of combination it exists in wine, cannot be easily ascertained. It is undoubtedly intimately combined with the other component parts of wine; as Fabroni has shown that it cannot be separated by saturating the wine with dry carbonate of potash, though a very small portion of alcohol, added on purpose to wine, may be easily separated by means of that salt. But if alcohol separate along with the carbonic acid during the fermentation, we can scarcely doubt that it has been formed. When wine is distilled, the alcohol readily separates. The distillation is usually continued as long as the liquid which comes over is inflammable. The quantity obtained, varies according to the wine, from a fourth to a fourteenth part of the wine distilled. The spirit thus obtained is well known under the name of brandy. Bullion has observed, that when wine is distilled new, it yields more alcohol than if it be allowed to get old. What remains after this distillation is distinguished in France by the name of *vinasse* It consists of tartar, &c. and when evaporated to dryness and subjected to combustion, yields potash

3. *Extractive matter* — This matter exists in all wines; but its proportion diminishes according to the age of the wine, as it gradually precipitates to the bottom.

4. Every wine is distinguished by a peculiar flavour and odour, which probably depends upon the presence of a volatile oil, so small in quantity that it cannot be separated.

5. The colouring matter of wine is originally contained in the husk of the grape, and is not dissolved till the alcohol be developed. This matter is analogous to the other colouring matters of plants; a set of bodies possessed of remarkable properties, but too little examined hitherto, to be introduced with much advantage into a system of chemistry. This colouring matter precipitates when the wine is exposed to the heat of the sun. It sometimes also precipitates in old wine, and it may be easily separated by pouring lime-water into wine.

The following table, containing the different substances which Neumann extracted from various wines, is worth preserving.

A quart of	Highly rectified Spirit.			Thick, oily, unctuous, resinous matter.			Gummy and tartarous matter			Water.			
	oz.	dr.	gr.	oz.	dr.	gr.	oz.	dr.	gr.	lb.	oz.	dr.	gr.
Aland	1	6	00	3	2	00	1	5	00	2	5	3	00
Alicant	3	6	00	6	0	20	0	1	40	2	2	6	00
Burgundy	2	2	00	0	4	00	0	1	40	2	9	0	20
Carcassonne	2	6	00	0	4	10	0	1	20	2	8	4	30
Champagne	2	5	20	0	6	40	0	1	00	2	8	3	00
French	3	0	00	0	6	40	0	1	00	2	8	0	20
Frontignac	3	0	00	3	4	00	0	5	20	2	4	6	30
Vin de Grave	2	0	00	0	6	00	0	2	00	2	9	0	00
Hermitage	2	7	00	1	2	00	0	1	40	2	7	5	20
Madeira	2	3	00	3	2	00	2	0	00	2	4	3	00
Malmsey	4	0	00	4	3	00	2	3	00	2	1	2	00
Vino de Monte Pulciano	2	6	00	0	3	00	0	2	40	2	8	0	20
Moselle	2	2	00	0	4	20	0	1	30	2	9	0	10
Muscadine	3	0	00	2	4	00	1	0	00	2	5	4	00
Neufschatel	3	2	00	4	0	00	1	7	00	2	2	7	00
Palm Sec	2	3	00	2	4	00	4	4	00	2	2	5	00
Pontac	2	0	00	0	5	20	0	2	00	2	9	0	40
Old Rhenish	2	0	00	1	0	00	0	2	20	2	8	5	40
Rhenish	2	2	00	0	3	20	0	1	34	2	9	1	06
Salamanca	3	0	00	3	4	00	2	0	00	2	3	4	00
Sherry	3	0	00	6	0	00	2	2	00	2	0	6	00
Spanish	1	2	00	2	4	00	9	4	00	1	10	6	00
Vino Tinto	3	0	00	6	4	00	1	6	00	2	0	6	00
Tokay	2	2	00	4	3	00	5	0	00	2	0	3	00
Tyrol red wine	1	4	00	1	2	00	0	4	00	2	8	6	00
Red wine	1	6	00	0	4	40	0	2	00	2	9	3	20
White	2	0	00	0	7	00	0	3	00	2	7	0	00

To this head belong not only common wine, but all the intoxicating liquors made from vegetable juices; as cyder from apples, perry from pears, currant wine &c. likewise the liquor made from the juice of the sugar cane, the sugar maple, &c.

In the Archives of Useful Knowledge, Vol. 1. No. 3. is a long essay on the cultivation of grapes, and the manufacture of wine, communicated by Mr. Cooper, to which we refer the reader. The latest improvements of Mr. Cooper, on the manufacture of wine, we deem of importance, and accordingly give them in his own language.

"I gather the grapes when fully ripe and dry, separate the rotten or unripe from the others, and press for distillation if the quantity is worth attending to; I then open the cider-mill, so as not to mash the stems or seed of the grapes; then run them through, put the pummice or mashed grapes, on some clean long straw, previously made damp, and laid on the cider-press floor, lap it in the straw, press it well, then take off the pummice and add some water, or I believe sweet unfermented cider would be better, and answer in lieu of sugar. After it has soaked awhile, (but do not let it ferment in the pummice,) press as before, put all together, and add sugar until it is an agreeable sweet. I have found a pound to a gallon, sufficient for the sourest grapes, and white Havanna sugar for the best; but sweet grapes make the best wine, without any sugar.

"I have heretofore recommended putting the sugar in, after fermentation, but on experience find it not to keep as well, and am now convinced that all the saccharine matter for making wine, should be incorporated before fermentation.—Previously to fermentation, I place the casks three or four feet from the floor; as the filth works out, fill it up two or more times a day, till it emits a clear froth, then check the fermentation gradually, by putting the bung on slack, and tighten it, as the fermentation abates.—

When the fretting has nearly ceased, rack it off: for which purpose I have an instrument nearly in the shape of a wooden shovel, with a gutter in the upper side of the handle; place it so as to prevent waste, and let it dribble into a tub slowly, which gives the fretting quality an opportunity to evaporate, tranquillizes the liquor, and hastens the maturity. When the cask is empty, rinse it with fine gravel, to scour off the yeast that adheres to it from fermentation, then for each gallon of wine put in one pint of good high proof French, or apple brandy, fill the cask about one-third, then burn a sulphur match in it; when the match is burnt out, stop the bung-hole, and shake it to incorporate the smoke and liquor; fill the cask, and place it as before, and in about a month rack it again as directed above; the gravel is unnecessary after the first racking. If the match should not burn well the first racking, repeat it; and if it don't taste strong enough to stand hot weather, add more brandy. I have racked my wine three or four times in a year, and find it to help its ripening; have frequently had casks on tap for years, and always found the liquor to improve to the last drawing.

"Being fully of opinion that our common wine grapes, are capable of producing wine as good and as palatable, (prejudice aside) and far more wholesome, than the wine generally imported at so great an expense: and a supply of that article being very uncertain, I am induced to urge the making wine of all the native grapes that can be procured; and in collecting them, to notice the vines that produce grapes of the best quality, and which are the most productive, as this will enable persons to select the best vine, to cultivate and propagate from. This ought to be particularly attended to, as there are many vines which produce good grapes, but few in quantity, and others very productive but of bad quality: and I believe full half the number, that come from the seeds are males, and will never bear fruit. The sex is easily distinguished when in bloom, by the females showing the fruit in the heart of the blossom, as soon as open, and the male presenting nothing of that kind.

"As the native grape-vine will not grow well from cuttings, the best way I know of, to propagate them, is by removing the vine, or laying branches in the earth to take root for a year or more, and when rooted remove them, or plant the seeds from the best kinds; and when in bloom dig up the males. If well cultivated, they will blow in three or four years, but will produce different kinds, the same as apples; and I have had some from the seeds superior to the parent."

We shall now mention the manner of making one or two other wines, as

Cider Wine.

This is made by evaporatng the fresh apple juice, in a brewers copper or other convenient vessel; and when it is half consumed, the remainder is to be conveyed to a wooden cooler, and then put into casks, and fermented with yeast in the usual way.

Currant Wine.

To 14 lbs. of currants put three gallons of water; break them; and after standing a day or two, express them. To the juice add 14 lbs. of sugar, and barrel it; in 14 days it will have fermented. After which bung the barrel, previously adding, one quart of brandy, to every 10 gallons.

All those nutritive, vegetable, and animal matters, which contain sugar ready formed, are susceptible of the spirituous fermentation. Thus wine may be made of all the juices of plants, the sap of trees, the infusions and decoctions of farinaceous vegetables, the milk of frugivorous animals; and lastly, it may be made of all ripe succulent fruits; but all these substances are not equally proper to be changed, into a good and generous wine.

As the production of alcohol is the result of the spirituous fermentation, that wine may be considered as essentially the best, which contains most alcohol. But of all substances, susceptible of the spirituous fermentation, none is capable of being converted into so good a wine, as the juice of the grapes of France, or of other countries, that are in the same latitude, or in the same temperature. The grapes of hotter countries, and even those of the southern provinces of France, do indeed furnish wines, that have a more agreeable, that is, more of a saccharine taste; but these wines, though they are sufficiently strong, are not so spirituous as those of the provinces near the middle of France: at least, from these latter wines, the best vinegar and brandy are made. As an example, therefore, of spirituous fermentation in general, we shall describe the method of making wine from the juice of the grapes of France.

The juice, when newly expressed, and before it has begun to ferment, is called *must*, and in common language sweet wine. It is turbid, has an agreeable and very saccharine taste. It is very laxative; and when drunk too freely, or by persons disposed to diarrhœas, it is apt to occasion these disorders. Its consistence is

somewhat less fluid than that of water, and it becomes of a pitchy thickness, when dried.

When the *must* is pressed from the grapes, and put into a vessel and place, in a temperature between 55 and 60° Fahr. very sensible effects are produced in it, in a shorter or longer time, according to the nature of the liquor, and the exposure of the place. It then swells, and is so rarefied, that it frequently overflows the vessel containing it, if this be nearly full. An intestine motion is excited among its parts, accompanied with a small hissing noise, and evident ebullition. The bubbles rise to the surface, and at the same time is disengaged a quantity of carbonic acid, of much purity.

The skins, stones, and other grosser matters of the grapes, are buoyed up by the particles of disengaged air, that adhere to their surface, are variously agitated, and are raised in form of a scum or soft and spongy crust, that covers the whole liquor. During the fermentation this crust is frequently raised, and broken by the air disengaged from the liquor which forces its way through it; afterwards the crust subsides, and becomes entire as before.

These effects continue while the fermentation is brisk, and at last gradually cease: then the crust being no longer supported, falls in pieces to the bottom of the liquor. At this time, if we would have a strong and generous wine, all sensible fermentation must be stopped. This is done by putting the wine into close vessels, and carrying these into a cellar or other cool place.

After this first operation, an interval of repose takes place, as is indicated by the cessation of the sensible effects, of the spirituous fermentation; and thus enables us to preserve a liquor no less agreeable in its taste, than useful for its reviving and nutritive qualities when drunk moderately.

If we examine the wine produced by this first fermentation, we shall find, that it differs entirely and essentially from the juice of grapes before fermentation. Its sweet and saccharine taste, is changed into one that is very different, though still agreeable, and somewhat spirituous and piquant. It has not the laxative quality of *must*, but affects the head, and occasions, as is well known, drunkenness.—Lastly, if it be distilled, it yields, instead of the insipid water obtained from *must*, by distillation with the heat of boiling water, a volatile, spirituous, and inflammable liquor, called spirit of wine, or alcohol. This spirit is consequently a new being, produced by the kind of fermentation, called the vinous or spirituous. See ALCOHOL.

When any liquor undergoes the spirituous fermentation, all its parts seem not to ferment at the same time, otherwise the fermentation would probably be very quickly completed, and the appearance would be much more striking: hence, in a liquor much disposed to fermentation, this motion is more quick and simultaneous, than in any other liquor. Experience has shown, that a wine, the fermentation of which is very slow and tedious, is never good or very spirituous; and therefore, when the weather is too cold, the fermentation is usually accelerated, by heating the place, in which the wine is made. A proposal has been made by a person very intelligent in economical affairs, to apply a greater, than the usual heat, to accelerate the fermentation of the wine, in those years, in which grapes have not been sufficiently ripened, and when the juice is not sufficiently disposed to fermentation.

A too hasty and violent fermentation is perhaps also hurtful, from the dissipation and loss of some of the spirit: but of this we are not certain. However, we may distinguish in the ordinary method, of making wines of grapes, two periods in the fermentation, the first of which lasts during the appearance of the sensible effects above-mentioned, in which the greatest number of fermentable particles ferment. After this first effort of fermentation, these effects sensibly diminish, and ought to be stopped for reasons, hereafter to be mentioned. The fermentative motion of the liquors then ceases. The heterogenous parts, that were suspended in the wine by this motion, and render it muddy, are separated, and form a sediment called the lees; after which the wine becomes clear: but though the operation is then considered as finished, and the fermentation apparently ceases, it does not really cease: and it ought to be continued in some degree, if we would have good wine.

In this new wine, a part of the liquor probably remains, that has not fermented, and which afterwards ferments, but so very slowly, that none of the sensible effects produced in the first fermentation, are here perceived. The fermentation therefore still continues in the wine, during a longer or shorter time, although in an imperceptible manner; and this is the second period of the spirituous fermentation, which may be called the imperceptible fermentation. We may easily per-

ceive, that the effect of this imperceptible fermentation is the gradual increase of the quantity of alcohol. It has also another effect no less advantageous, namely, the separation of the acid salt called tartar from the wine. This matter is therefore a second sediment, that is formed in the wine, and adheres to the sides of the containing vessels. As the taste of tartar is harsh and disagreeable, it is evident, that the wine, which by means of the sensible fermentation has acquired more alcohol, and has disengaged itself of the greater part of its tartar, ought to be much better and more agreeable; and for this reason chiefly, old wine is universally preferable to new wine.

But insensible fermentation can only ripen and meliorate the wine, if the sensible fermentation have regularly proceeded, and been stopped in due time. We know certainly, that if a sufficient time have not been allowed for the first period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles, or close vessels in which the wine is put, and will occasion effects so much more sensible, as the first fermentation shall have been sooner interrupted: hence these wines are always turbid, emit bubbles, and sometimes break the bottles, from the large quantity of air disengaged during the fermentation.

We have an instance of these effects in the wine of Champagne, and in others of the same kind. The sensible fermentation of these wines is interrupted, or rather suppressed, that they may have this sparkling quality. It is well known, that these wines, make the corks fly out of the bottles, that they sparkle and froth when they are poured into glasses, and lastly, that they have a taste much more lively, and more piquant than wines that do not sparkle; but this sparkling quality, and all the effects depending on it, are only caused by a considerable quantity of carbonic acid gas, which is disengaged during the confined fermentation, that the wine has undergone in close vessels. This air not having an opportunity of escaping, and of being dissipated as fast as it is disengaged, and being interposed betwixt all the parts of the wine, combines in some measure with them, and adheres in the same manner, as it does to certain mineral waters, in which it produces nearly the same effects. When this air is entirely disengaged from these wines, they no longer sparkle, they lose their piquancy of taste, become mild, and even almost insipid.

Such are the qualities that wine acquires in time, when its fermentation has not continued sufficiently long. These qualities are given purposely, to certain kinds of wine, to indulge taste or caprice; but such wines are supposed to be unfit for daily use. Wines for daily use ought to have undergone so completely the sensible fermentation, that the succeeding fermentation shall be insensible, or at least exceedingly little perceived. Wine, in which the first fermentation has been too far advanced, is liable to worse inconveniences, than that in which the first fermentation has been too quickly suppressed; for every fermentable liquor is from its nature in a continual intestine motion, more or less strong, according to circumstances, from the first instant of the spirituous fermentation, till it is completely putrefied: hence from the time of the completion of the spirituous fermentation, or even before, the wine begins to undergo the acid, or acetous fermentation. This acid fermentation is very slow and insensible, when the wine is included in very close vessels, and in a cool place; but it gradually advances, so that in a certain time the wine, instead of being improved, becomes at last sour. This evil cannot be remedied; because the fermentation may advance, but cannot be reverted.

Wine-merchants, therefore, when their wines become sour, can only conceal or absorb this acidity by certain substances, as by alkalies and absorbent earths. But these substances give to wine a dark greenish colour, and a taste which, though not acid, is somewhat disagreeable. Besides, calcareous earths accelerates considerably, the total destruction and putrefaction of the wine. Oxyds of lead, having the property of forming with the acid of vinegar, a salt of an agreeable saccharine taste, which does not alter the colour of the wine, and which besides has the advantage of stopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occasion most terrible cholics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil consequences of lead, would for the sake of gain, employ it for the purpose mentioned; but if there be any such persons, they must be considered as the poisoners and murderers of the public. At Alicant, where very sweet wines are made, it is the practice, to mix a little lime with the grapes, before they are pressed. This, however, can only neutralize the acid already existing in the grape.

If wine contain litharge, or any other oxide of lead, it may be discovered by evaporating some pints of it to dryness, and melting the residuum in a crucible, at the bottom of which a small button of lead may be found after the fusion; but an easier and more expeditious proof is by pouring into the wine some liquid sulphuret. If the precipitate occasioned by this addition of the sulphuret be white, or only coloured by the wine, we may know, that no lead is contained in it; but if the precipitate be dark coloured, brown or blackish, we may conclude, that it contains lead or iron. The test by Hahnemann, (which see under the head of Tests) however, precipitates only lead and copper, black, arsenic of an orange colour, and does not throw down iron.

Wine, which might have been long preserved in a cool place, very quickly becomes sour when placed in a bad cellar; and even as the best cellars have during winter a degree of heat much above that of the atmosphere, it would be very proper, when wine disposed to become sour is to be preserved, to bring it from the cellar in the beginning of winter, and leave it exposed to the air during all that season.

Wine is also liable to various other changes; such as to become ropy and mucilaginous, by the continuance of the fermentative motion.

Wine, and the matters produced from wine, as brandy, spirit of wine, vinegar, lees of wine, tartar, are greatly and extensively useful. The lees of wine are employed in the manufacture of hats. These lees, and also tartar, by incineration, yield a larger quantity than any other vegetable matter of pure fixed alkali.

Wine has been preferred at all times and in all countries to every other alimentary liquor. We may say in general, that it is good and salutary, when taken in small quantities, and that it is pernicious when drunk habitually and in too large quantities. Wine becomes then a true slow poison, which is so much more dangerous, as it is more agreeable. But if we observe more particularly the effects of wine, we shall perceive very great differences depending on different constitutions. Some persons drink habitually large quantities of pure wine, without any sensible inconvenience or disease, or apparently shortening their lives; but, on the contrary, many others do also entirely destroy their health and shorten their lives by an habitual use of wine, even in small quantity, and mixed with water—although it is always more safe and prudent for every person to drink little of it habitually, and this moderation is more indispensably necessary to those whose constitutions wine does not suit.

As the diseases consequent upon the too free use of wine, come on gradually and insensibly, sometimes even during many years, several persons, especially men otherwise very sober and attentive to health, are every day deceived in this article, drinking more wine than is suitable to their constitution, and gradually ruining their health, without knowing the cause. It is therefore a matter of importance, to show the signs by which wine may be known to be hurtful.

We may know that wine does not suit a person, when, after drinking moderately of it, his breath acquires a vinous smell; when it occasions sour belchings and slight pains in the head; and when, after drinking it more copiously than usual, it produces stupefaction, nausea and drunkenness, especially when this drunkenness is of the morose, peevish, quarrelsome, and irascible kind. Unhappy is that person who suffers these effects from wine, and notwithstanding persists in the habitual use of it. These imprudent persons never fail of coming to a miserable death, preceded by languor, and premature; their common age being about fifty years, or a little more. The diseases to which they are most subject are obstructions in the liver, in the mesenteric glands, and in other abdominal viscera, which are almost always succeeded by an incurable dropsy. Those who digest wine well do not suffer, or much less sensibly, the above-mentioned effects of drinking it. Their drunkenness is accompanied with vivacity and joy. Such persons seldom die of the obstructions and dropsy above-mentioned; but wine is nevertheless so much more dangerous to them, that, as they suffer none of the disagreeable effects, they are more liable to contract the habit of drinking too much. Drinkers of this class generally live somewhat longer than the former; but their constitution changes before sixty years of age; and the inheritance of their old age is either a severe gout or palsy, stupidity, imbecility, or an accumulation of these diseases.

We need not mention that the too frequent use of brandy, liqueurs, as they are called, or cordials, and other spirituous liquors, is still more pernicious and fatal than that of wine.

Wine is used in medicine as a vehicle in the composition of many internal and external remedies. As wine is composed of alcohol, water, extractive saponaceous

matter, and acid of tartar, it may be very usefully employed for the extraction of almost all the proximate principles, and consequently of the medicinal parts, of vegetables. Many extracts are made with wine, which may be considered as being more complete than those made with water; but physicians who prescribe these extracts, ought to remember, that, beside the principles of the vegetables, they also contain the extractive part of the wine, that is, all the principles of wine, excepting the alcohol, which is too volatile to remain in an extract.

As wine when good may be preserved during a long time, several medicinal wines prescribed in dispensatories, are kept in the shops of apothecaries. In many cases, as in several chronical diseases, where tonic, cordial, fortifying, and exciting remedies are indicated, physicians prefer the use of wine to water, as a vehicle for the infusion of purgative, opening, and other medicinal substances. See Alcohol.

In addition to the remarks already made, the following miscellaneous observations we take from the memoir of C. Chaptal, entitled "A Treatise on the cultivation of the Vine, and the method of making Wines."

The faults of fermentation arise naturally from the quality of the grapes, which are the subject of it; and from the temperature of the air, which may be considered as a very powerful auxiliary.

Grapes may not contain a sufficiency of sugar to produce a sufficient formation of alcohol; and this vice may be owing to the grapes not having attained to maturity, or to the sugar being diluted in too considerable a quantity of water; or because sugar, by the nature of the climate, cannot sufficiently develope itself In all cases there are two ways of correcting the vice which exists in the nature of the grapes: the first consists in conveying into the *must* that principle which it wants: a proper addition of sugar presents to fermentation the materials necessary for the formation of alcohol, and the deficiency of nature is supplied by art. The antients, it appears, were acquainted with this process, since they mixed honey with the *must* which they caused to ferment.

Experiments seem to prove, beyond all doubt, that the best method of remedying the want of maturity in grapes, is to follow the process indicated by nature; that is to say, to introduce into the *must* that quantity of saccharine principle necessary, which it could not give them. This method is the more practicable, as not only sugar, but also honey, molasses, and every other saccharine matter of an inferior price, can produce the same effect, provided they have no disagreeable acetous taste which cannot be destroyed by good fermentation.

Bullion, caused the juice of grapes, taken from his park at Bellegames, to ferment by adding from 15 to 20 pounds of sugar per *muid* (280 quarts). The wine they produced was of a good quality.

Rozier, long ago, proposed to facilitate the fermentation of *must*, and ameliorate wines by the addition of honey, in the proportion of a pound, to two hundred of *must*.

It is possible also to correct the quality of the grapes by other means, which are daily practised. A portion of the must is boiled in a kettle; it is concentrated to one-half, and then poured into a vat. By this method the aqueous portion is in part dissipated, and the portion of sugar being then less diluted, the fermentation proceeds with more regularity, and the produce is more generous. This process, almost always useful in the north, cannot be employed in the south, but when the season has been rainy, or when the grapes have not been sufficiently ripe.

The same end may be attained by drying the grapes in the sun, or exposing them for the same purpose, in stoves, as is practised in some wine countries.

It is perhaps for the same reason, always with a view to absorb the moisture, that plaster is sometimes put into the vat, as was practised by the ancients.

It sometimes happens that the *must* is both too thick, and too saccharine. In that case the fermentation is always slow and imperfect: the wines are sweet, luscious, and thick; and it is not till after remaining a long time in the bottles, that it becomes clear, loses its disagreeable thickness, and only exhibits good qualities. The greater part of the white Spanish wines are in this situation. This quality of wine has however its partisans, and there are some countries where the *must* is concentrated for that purpose; in others the grapes are dried in the sun or in stoves till they are reduced almost to the consistence of an extract.

It would be easy in all cases to excite fermentation, either by diluting the *must*, when too thick, with water, or by agitating the vintage in proportion as it ferments: but all this must be subordinate to the end proposed to be obtained, and the intelligent vintner will vary his processes according to the effect which he intends to produce.

It must never be forgotten, that the fermentation ought to be managed according to the nature of the grapes, and agreeably to the quality of the wine that may be required.

In cold countries, where the grapes are very aqueous, and little saccharine, they ferment with difficulty. Fermentation in that case may be excited by two or three principal means :

1st, By the help of a funnel of tin plate with a very wide tube, which descends to within four inches of the bottom of the vat, and through which boiling *must* is introduced into it Two pailfuls may be used for 300 bottles of *must*. This process, proposed by Maupin, has produced good effects.

2d, By shaking the vintage from time to time. This motion is attended with this advantage, that it renews the fermentation when it has ceased or become weak, and causes it to be uniform throughout the mass.

3d, By laying a covering not only over the vintage, but round about the vat.

4th, By heating the atmosphere of the place in which the vat stands.

The antients mixed aromatic substances with the vintage in a state of fermentation, in order to give their wines peculiar qualities. We are told by Pliny, that it was usual in Italy to sprinkle pitch, and resin over the vintage, *ut odor vino contingeret et saporis acumen.* In all the works of that period, we find numerous recipes for perfuming wines ; but these different processes are no longer used. I am, however, inclined to think that they were of great benefit. This very important part of oinology, deserves the particular attention of the agriculturist. When we consider the custom followed in some countries, of perfuming the wines with rasberries, the dried flowers of the vine, &c. we may even presage the happiest effects from it.

The method of taking the Wine from the Vats, and the proper period for that purpose.

At all times agriculturists have considered it as a matter of great importance, to be able, by unerring signs, to discover the most favourable period for taking the wine from the vats ; but here, as in other things, they have fallen into the very great inconvenience of general methods. This period ought to vary according to the climate, the season, and the nature of the wine proposed to be obtained, and of other circumstances, which must always be kept in view.

According to principles deduced from theory, we may draw the following consequences.

1st, The *must* ought to remain in the vats the less time, according as it is less saccharine. Light wines, called in Burgundy, *vins de primeur*, cannot bear the vat above from six to twelve hours.

2d, The *must* ought to remain the less time in the vats, according as it is proposed to retain the acid gas, and to form brisk wines. In that case, it is thought sufficient to tread the grapes, and to put the juice into the casks after it has been left in the vat twenty-four hours, and sometimes without having been in the vat at all. In this case, the fermentation on the one hand, is less tumultous ; and, on the other, the gas can with less ease be volatilized, which contributes to retain that highly volatile substance, and to make it one of the principles of the liquor.

3d, *Must* ought to be left in the vats less time, according as it is proposed to obtain wine less coloured. This condition is of great importance in regard to brisk wines, one of the most valuable qualities of which is their want of colour.

4th, *Must* ought to remain in the vats less time, according as the temperature is warmer, and the mass more voluminous, &c. In that case, the briskness of the fermentation makes up for its shortness of duration.

5th, The *must* ought to remain in the vats less time, according as it is proposed to obtain wine of a more agreeable flavour.

6th, The fermentation, on the other hand, will be longer, according as the saccharine principle is more abundant, and the *must* thicker.

7th, It will be longer if the wines are destined for distillation ; in which case, every thing ought to be sacrificed to the production of alcohol.

8th, The fermentation will be longer, according as the temperature has been colder, when the grapes were collected.

9th, The fermentation will be longer, according as the wine is required to be more coloured.

A provident agriculturist will always prepare his casks, on the approach of the vintage, in such a manner that they may be ready to receive the wine as it comes from the vat. The preparation given to them, is as follows ;

If the casks are new, the wood of which they are composed retains an astringency and bitterness, which may be transmitted to the wine ; and these faults may be corrected by pouring warm water and salt

water, into them several times in succession. These liquors must be well shaken, and suffered to remain in them till they penetrate the texture of the wood, and extract the pernicious principle. If the casks are old, and have been frequently employed, one end of them is opened: the stratum of tartar, with which the inside is covered, is scraped off, and they are washed with warm water or with wine.

In general, the most usual methods of preparing the casks are confined to the following.

1st, Wash the cask with cold water, then pour into it a quart of salt water, in a state of ebullition; stop the bung-hole, and shake it in every direction; empty it, let the water drain well off; then take two quarts of fermenting *must*, and, having boiled and skimmed it, pour it boiling hot into the cask; close it and again shake it, after which suffer it to drain off.

2d, Warm wine may be employed instead of the above preparations.

3d, An infusion of the flowers of the peach-tree, &c, may also be used.

When the casks have acquired any bad quality, such as mustiness, &c. they must be burnt. It is possible to conceal these defects, but there is reason to fear they might re-appear.

The antient Romans put gypsum, myrrh and various aromatic substances into the casks into which their wines were removed from the vat. This is what they called *conditura vinorum*. The Greeks sometimes added a little bruised myrrh and argil. These substances not only perfumed the wine, but served also to clarify it.

The wine of the press is the less coloured, according as it is pressed more weakly and more speedily. These wines in Champagne, are called *gray wines*. The wine arising from the first and second cutting, is called *œil de perdrix;* and that arising from the third and fourth, *vin de taille*. The last is the most coloured, but still agreeable.

The refuse, when strongly pressed, acquires sometimes the hardness of stone. It is applied to various uses in commerce.

1st, In some countries it is distilled in order to make a spirit, which is called *eau-de-vie de marc*. In Champagne it is known under the name of *eau d'Aixne;* but it has a bad taste. This distillation is advantageous, especially in countries where the wine is highly generous, and where the presses do not press very closely.

2d, In the neighbourhood of Montpellier, the refuse is put into casks, where it is carefully trod upon; and it is then preserved for making verdigris.

3d, In other places it is rendered acid by carefully airing it, and the vinegar is then extracted by strong pressure. The expression may even be facilitated by moistening it with water.

4th, In several cantons the cattle are fed with the refuse. As it comes from the press, it is broken with the hands in order to divide the lumps; it is then thrown into casks, where it is moistened with water, and it is covered with earth mixed with straw. This covering is about 7 or 8 inches in thickness. When bad weather prevents the cattle from going out into the fields, about 6 or 7 pounds of this refuse is soaked in warm water with bran, straw, turnips, potatoes, oak, and vine leaves, which have been preserved on purpose in water. A little salt may be added to this mixture, which is given to the cattle in a tub evening and morning. Horses and cows are fond of this food; but it must be given to the latter in moderation, because it would cause their milk to turn sour. The refuse of white grapes is preferred on account of its not having been fermented.

5th, The stones contained in the grapes serve for feeding poultry. Oil, also may be extracted from them.

6th, The refuse may be burnt to obtain alkali. 4000 pounds of refuse yields 500 pounds of ashes, which give 10 pounds of dry alkali.

Of the method of managing the Wine in the Casks.

The wine deposited in the casks has not reached its last degree of preparation. It is turbid, and still ferments; but, as the movement of it is less tumultous, this state of it has been called the insensible fermentation.

Soon after the wine has been put into the cask, a slight hissing is heard, which arises from the continued disengagement of the carbonic acid gas, that escapes from every point of the liquor; foam, which passes over through the bung-hole, is formed at the top, and care is taken to keep the cask always full, that the foam may escape, and that the wine may disgorge itself. For a short time it will be sufficient to fasten a piece of paper on the bung, or to lay a tile over it.

In proportion as the fermentation decreases the mass of the liquid sinks down; and this depression is carefully watched, in order to pour in more wine, that the casks may be always kept full. There

are some countries where this operation is performed every day for the first month, every four days for the second, and every eight till it is drawn off. This is the method practised in regard to the delicious wines of the Hermitage.

Every thing that relates to the art of preserving wines, may be reduced to sulphuring and clarification.

Sulphuring of Wine.

1st, To sulphur wine is to impregnate it with a sulphurous vapour, obtained by the combustion of sulphured matches.

The method of composing these matches varies considerably in different places; some mix with the sulphur aromatic substances, such as powder of cloves, cinnamon, ginger, Florentine iris, flowers of thyme, lavender, marjorum, &c. and melt the mixture in an earthen vessel over a moderate fire. in this melted mixture, rags of cotton cloth are dipped in order to be burnt in the casks. Others employ sulphur alone, which they melt over the fire, and dip rags in it in the same manner.

In the method of sulphuring casks there is also considerable variety. Sometimes the match is suspended at the end of an iron wire; it is then lighted, and put into the cask intended to be filled with the wine; the cask is then stopped, and the match is then left to burn. The internal air becomes dilated, and is expelled, with a hissing noise, by the sulphurous gas. Two, three, or more matches are burnt in this manner, according as may be thought necessary. When the combustion is terminated, the sides of the cask are scarcely acid; the wine is then poured into it. In other countries, two or three pailsful of wine are poured into a good cask; a sulphured match is then burnt in it; and when the combustion is finished, the cask is stopped, and shaken in every direction. After being left at rest for an hour or two, it is unstopped, more wine is added; it is then again sulphured and the operation is repeated till the cask be full. This is the process usually followed at Bordeaux.

At Marseillan, near the commune of Cette, in Languedoc, a kind of wine is made of white grapes, called *mute wine*, which is employed to sulphur others. The vintage is trod and pressed without giving it time to ferment; it is then put into casks filled one-fourth; several matches are burnt over it; and the casks are strongly skaken, until no more gas escapes through the bung-hole when opened. A new quantity of wine is then added, matches are again burnt over it, and the casks are shaken with the same precautions. This operation is repeated till the cask is full. This wine never ferments, and for that reason is called mute wine (*vin muet.*) It has a sweetish savour, a strong sulphurous odour, and is employed for mixing with other wine. Two or three bottles of it are put into a cask. This mixture is equivalent to sulphuring.

Sulphuring first renders wine turbid, and gives it a bad colour; but the colour is restored in the course of time, and the wine becomes clear. This operation whitens the wine a little. Sulphuring is attended with the very valuable advantage of preventing its becoming acetous.— Though it be difficult to explain this effect, it appears to me that it cannot be conceived but by considering it under two points of view:

1st, By the help of the sulphurous gas the atmospheric air is displaced, which otherwise would become mixed with the wine, and determine acid fermentation.

2d, Some atoms of a violent acid, which opposes and overcomes the developement of a weaker acid, are produced.

The antients composed a kind of mastic with pitch, a fiftieth part of wax, and a little salt and incense, which they employed for burning in their casks. This operation was denoted by the words *picare dolia*, and the wines thus prepared were known under the names of *vina picata*. They are mentioned by Plutarch and Hippocrates.

It was, perhaps, in consequence of this custom, that the fir was consecrated by the antients to Bacchus. At present, an agreeable perfume is communicated to weakened red wine, by making it remain over a stratum of the shavings of fir. Baccius says that the casks ought to be pitched (*picare dolia*) during the dog days.

On the Clarification of Wines.

2d, Besides the operation of sulphuring wines, there is another, no less essential, called clarification. It consists, in the first place, in drawing off the wine from the lees, which requires certain precautions, and in then disengaging it from all the principles suspended or weakly dissolved in it; so that nothing may be retained but the spirituous and incorruptible principles alone. These operations are even performed before that of sulphuring, which is only a continuation of them.

The first of these operations is called drawing off, transvasation, defecation. According to Aristotle, this ought to be oft-

en repeated: quoniam superveniente æstatis calore solent fæces subverti, ac ita vina acescere.

In the different wine countries, there are certain fixed periods of the year for this operation, established, no doubt, on the constant and respectable observation of ages. At the Hermitage, the wine is drawn off in March and September; in Champagne, on the 13th of October, about the 15th of February, and towards the end of March.

Dry, cold weather is always chosen for this operation. It is certain that it is then only that the wine is in a good condition. Damp weather, and southerly winds, always render wine turbid; and care must be taken not to draw it off while these prevail.

Baccius has left some excellent precepts respecting the most favourable periods for the defæcation of wine. He advises the weakest wines, that is to say, those produced from fat covered soil, to be drawn off at the winter solstice; moderate wines in the spring; and the most generous, during summer. He gives as a general precept, not to draw off the wine but when the north wind prevails; and he adds, that wine drawn off at the time of the full moon, is converted into vinegar!

The manner in drawing off wine can be a matter of indifference only to those unacquainted with the effect of atmospheric air on that liquid. By opening the tap, or placing a cock at about four inches from the bottom of the cask, the wine which runs off becomes aerated, and determines movements in the lees; so that, under this double view, the wine acquires a disposition to become sour. A part of these inconveniences has been obviated by drawing off the wine by means of a syphon: the motion is then gentler, and by these means one may penetrate to any depth at pleasure, without agitating the lees. But all these methods are attended with faults, which have been completely remedied by the help of a pump, the use of which has been established in Champagne and other wine countries.

To a leathern pipe, of from four to six feet in length, and two inches in diameter, are adapted at each end wooden pipes, nine or ten inches in length, which decrease in diameter towards the ends, and are fixed to the leathern pipe by means of a piece of pack-thread. The bung of the cask intended to be filled, is taken out, and one of the extremities of the pipe is put into it. A good cock is fixed in the cask to be emptied, two or three inches from the bottom, and into this, is inserted the other extremity of the pipe.

By this mechanism alone, the half of the one cask is emptied into the other. For this purpose nothing is necessary but to open the cock; and the remainder may be made to pass by a very simple process, for which a pair of bellows, about two feet in length, comprehending the handles, and ten inches in breadth, are employed. The bellows force the air through a hole formed at the anterior part of the small end. A small leathern valve, placed below the small hole, prevents the air from rushing out when the bellows are opened, and to the extremity of the bellows is adapted a perpendicular wooden pipe to convey the air downwards. This tube is fitted into the bung-hole in such a manner, that when the bellows are worked and the air forced out, a pressure is exercised on the wine, by which means it is obliged to issue from the one cask, and to ascend into the other. When a hissing is heard at the cock, it is speedily shut. This is a sign that all the wine has passed.

Funnels of tin plate, the tubes of which are at least a foot and a half in length, that they may be immersed in the liquor without causing any agitation, are also employed.

Drawing off wine separates a part of its impurities, and consequently removes some of those causes which may alter the quality of it. But there still remain some suspended in the liquor, which cannot be caught, but by the following operations, which are called fining of wine, or clarification. Fishglue (isinglass) is almost always employed for this purpose. It is unrolled with care, and cut into small morsels, and it is then steeped in a little wine, where it swells up, becomes soft, and forms a viscid mass, which is poured into the wine. The wine is then strongly agitated, after which it is left at rest. Some whip the wine, in which the glue has been dissolved, with a few twigs of birch, &c. and by these means occasion a considerable foam, which is carefully removed. In all cases a portion of the glue is precipitated with the principles it has enveloped, and the liquor is drawn off when the deposit is formed.

A quarter cask of wine, may be well fined by drawing off about a quart of it, and mixing this well with a half a pint of new milk: which mixture is then to be put into the wine, and the cask well shaken, or rolled about. Then place the cask in the position in which it is to remain, taking care that it be so situated as to be in a

state of perfect rest, and in a few days the wine will be completely clear and fit for use.

In warm climates the use of the glue is dreaded, and during summer its places is supplied by whites of eggs. Ten or twelve are sufficient for half a muid (about a 72 gallon cask English) The eggs are first beat up with a little wine; they are then mixed with the liquor intended to be clarified, and it is whipped with the same care. It is possible that gum arabic might be substituted for glue. Two ounces will be sufficient for four hundred pots of wine. It is put into the liquor in the form of a fine powder, and the liquor is then stirred.

Wine must not be drawn off, till it is completely made. If the wine is green and harsh, it must be suffered to ferment a second time on the lees, and must not be drawn off till towards the middle of May; if it continues green, it may even be left till the end of June. It even sometimes happens that it is necessary to convey back the wine to the lees, and to mix them strongly, that the wine may again acquire that movement of fermentation which is necessary to bring it to perfection.

We are told by Miller, that when Spanish wine becomes turbid by the lees, it may be clarified by the following process:

Put the whites of eggs, gray salt, and salt water, into a convenient vessel; skim off the foam formed at the surface, and pour the composition into the wine cask from which a part of the liquor has been drawn off. At the end of two or three days the liquor becomes clear, and acquires an agreeable taste. After being suffered to remain at rest for about a week, it is then drawn off.

To revive claret injured by floating lees, two pounds of calcined flints, well pounded, ten or twelve eggs, and a large handful of salt, are beat up with two gallons of wine, which are then poured into the cask. Two or three days after, the wine is drawn off.

These compositions may be varied without end. Sometimes starch is employed, and also rice, milk, and other substances, more or less capable of developing the principles which render the wine turbid.

Wine is clarified also, and its bad taste is often corrected, by making it digest over shavings of beech wood, previously stripped of the bark, boiled in water, and dried in the sun, or in a stove. A quarter of a bushel of these shavings will be sufficient for a muid of wine. They produce a light movement of fermentation in the liquor, which becomes clear in the course of twenty-four hours.

The art of *cutting wines* (couper du vin) as it is called, (correcting one wine by another—giving a body to those wines which are weak—colour to those destitute of it—and an agreeable flavour to those which have none, or which have a bad one) cannot be described. In these cases, the taste, sight, and smell must be consulted. The highly variable nature of the substances employed, must be studied: and it will be sufficient for us to observe, that in this part of the management of wines, every thing consists: 1st, in sweetening wines, and rendering them saccharine by the addition of baked *must*, concentrated with honey, sugar, or another wine of a very luscious quality. 2d, colouring the wine by an infusion of turnsole cakes, the juice of elder-berries, logwood, and mixing it with dark, and, generally, coarse wine. 3d, perfuming it by syrup of rasberries, an infusion of the flowers of the vine, suspended in the cask, tied up in a bag, as is practised in Egypt, according to the testimony of Hasselquist.

Whatever may be the nature of the vessels destined to contain wine, a cellar sheltered from all accidents must be chosen.

1st, The exposure of the cellar must be northern. Its temperature is then less variable, than when the apertures are turned towards the south.

2d, It must be of such a depth that the temperature may be constantly the same. *In cellis quæ non satis profundæ sunt diurni caloris participes fiunt; vina non diu subsistunt integra*, says Hoffman.

3d, The moisture in it must be constant, without being too great: excess of moisture renders the papers, corks, casks, &c. mouldy. Dryness desiccates the casks and makes them leak.

4th, The light ought to be very moderate. A strong light dries; darkness, almost absolute, rots.

5th, The cellar must be sheltered from shocks. Violent agitation, or that shaking occasioned by the rapid passage of carriages along the street, agitates the lees, mixes them with the wine, where they are kept suspended, and occasions acetification. Thunder, and all movement occasioned by shocks, produce the same effect.

6th, Green wood, vinegar, and all substances susceptible of fermentation, must be kept at a distance from the cellar.

7th, The reverberation of the sun,

which, as it necessarily changes the temperature of a cellar, must also alter the properties of the wine preserved in it, ought also to be guarded against.

A cellar, therefore, must be dug to the depth of some fathoms below ground; its apertures ought to be directed towards the north; it must be at a distance from the street, highways, workshops, sewers, necessaries, &c. and ought to be arched at the top.

Maladies of Wine, and the Means of Preventing or Correcting them.

There are some wines which improve by age, and which cannot be considered as perfect, till a long time after they have been made. Luscious wines are of this kind, as well as highly spirituous wines; but delicate wines are so apt to turn sour, or oily, that it is only by means of great precaution, that they can be preserved for several years.

Among the diseases to which wines are most subject, oiliness and acidity, are the most common and most dangerous.

Oiliness is an alteration which wines often contract: they lose their natural fluidity, and become ropy, like oil.

The less spirituous wines turn oily; and weak wines, which have fermented very little, are the most disposed to this malady. Weak wines, made from grapes which have been picked, are also subject to it.

Wine turns oily in the best corked bottles. Of this there are too frequent instances in Champagne, where the wine of a whole vintage, when put into glass vessels, is exposed sometimes to this alteration.

Oily wines furnish by distillation, but a little fat coloured and oily spirit.

This fault may be corrected several ways.

1. By exposing the bottles to the air, and, above all, in a well-aired barn.

2. By shaking the bottle for a quarter of an hour; then uncorking it, and suffering the gas and foam to escape.

3 By mixing the wine with fish-glue, and whites of eggs mixed together.

4. By introducing into each bottle one or two drops of lemon juice, or any other acid.

Acescence of wine is however the most common malady, and we may even say, the most natural, for it is almost a consequence of spirituous fermentation; but by knowing the cause which produces it, and the phenomena which accompany or announce it, means may be taken to prevent it. The antients admitted three principal causes of the acidity of wines.

1. The humidity of the wine.

2. The inconstancy or variations of the atmosphere.

3. Commotions.

To know this malady exactly, we must call to mind some principles, which can alone furnish us with light on this subject.

1. Wine never turns sour, until the spirituous fermentation is terminated; or, in other words, till the saccharine principle is completely decomposed. Hence the advantage of putting wine into casks before all the saccharine principle has disappeared; because the spirituous fermentation then continues, is prolonged, and removes every thing that can pave the way, for acetous decomposition. Hence the practice of putting a little sugar into the bottle, to preserve the wine without alteration; and hence the general method of baking a part of the *must*, at a slow and moderate heat, and of mixing some of it in the casks, intended for embarkation. In some places of Spain and Italy, all the *must* is baked; and Bellon says, that the wines of Crete would not keep at sea, unless the precaution were taken to boil them.

2. The least spirituous wines, are those which soonest become sour. We know, by experience, that when the season is rainy, if the grapes be a little saccharine, which consequently gives a little alcohol, the wines readily turn sour. The weak wines of the north, become sour with great ease; while the strong, generous, spirituous wines, obstinately resist acidity.

It is however no less true, that the most spirituous furnish the strongest vinegar, though their acetification is more difficult, because alcohol is necessary to the formation of vinegar.

3. Wine, perfectly free from all extractive matter, either in consequence of its being deposited naturally, by time or by clarification, is not susceptible of turning sour. I have exposed old wine in uncorked bottles, to the ardour of the sun of July and August, for more than forty days, without the wine losing its quality; only the colouring principle was constantly precipitated under the form of a membrane, which covered the bottom of the bottle. The same wine, in which I infused vine-leaves, became sour in a few days. It is known that old wines, well purified, do not turn sour.

4. Wine does not acidify, or become sour, but when in contact with the air: atmospheric air mixed with wine, is a real leaven of acidity. When wine grows flat, (*se pousse*) it suffers to escape, or exhales, the gas it contains, and the external air then enters to assume its place.

5. There are certain times in the year, when the wine turns more readily sour. These periods are, the moment when the sap rises in the vine, when it flowers, or when the grapes assume a reddish tint. It is during these periods, in particular that precautions must be taken, to prevent its becoming acid.

6. Change in the temperature also promotes acidity, especially when the heat rises to 80 or 90 degrees, Fahr. The degeneration is then rapid, and almost unavoidable.

The acidity of wine may be easily prevented, by removing all those causes before-mentioned, which tend to produce this alteration; and when it has begun, it may be remedied by the means, more or less effectual, which we are going to mention.

Baked *must*, honey, or liquorice, are dissolved in wine, in which acidity has manifested itself; by these means its sour taste is corrected, being concealed by the sweetish savour of these ingredients.

The little acid which has been formed, may be seized by the means of ashes, alkalies, chalk, lime, and even litharge.— This last substance, which forms a very sweet salt with acetous acid, is exceedingly dangerous.

The works of oinologists abound with recipes, of greater or less value, for correcting the acidity of wine.

Bidet says, that about a 50th of skimmed milk, added to sour wine, restores it; and that it may be drawn off in five days.

Others take four ounces of the best wheat, boil it in water till it bursts; and, when it has cooled, put it into a small bag, which is immersed in the cask, shaking it with a stick.

Some recommend also the seeds of leeks, fennel, &c.

To show the futility of the greater part of these remedies, it will be sufficient to observe, that it is impossible to make fermentation proceed in a retrograde manner, and that it can, at most, be suspended; that the whole of the acid then formed, may be seized, or its existence may be concealed, by sweet and saccharine principles.

But besides these alterations, there are others, which, though less common and dangerous, deserve to be noticed. Wine sometimes contracts, what is called a taste of the cask. This malady may arise from two causes.

1. When the wine is put into casks, the wood of which is rotten or damaged.

2. When lees have been left to dry in the casks, into which new wine is put.— Willermoz proposes lime-water, carbonic acid, and oxygenated muriatic acid, to correct the bad taste arising from the cask: others recommend mixing the wine with isinglass, drawing it carefully off, and infusing roasted wheat in it for two or three days.

A phenomenon, which has struck and embarrassed the numerous authors who have spoken of the diseases of wine, is what is called the flowers of wine. These are formed in casks, but particularly in bottles, in which they occupy the neck; they constantly announce and precede the acid degeneration of wine. They manifest themselves in almost all fermented liquors, and always more or less abundantly, according to the quantity of extractive matter, existing in the liquor.

Uses and Virtues of Wine.

Wine has become the most useful beverage of man, and is, at the same time, the most varied. Wine is known in all climates; and the attraction of this liquor is so strong, that the prohibitory law respecting it, which Mahomet imposed on his followers, is daily broken.

This liquor, besides being a tonic and strengthener, is also more or less nutritive; in every point of view, it must be salutary. The antients ascribed to it the property of strengthening the understanding. Plato, Æschylus, and Solomon, all agree, in ascribing to it this virtue. But no writer has better described the real properties of wine, than the celebrated Galen, who assigns to each sort its peculiar uses, and describes the difference they acquire by age, climate, &c.

Excess in regard to the use of wine, has at all times called forth the censure of legislators. It was customary among the Greeks to prevent intoxication, by rubbing their temples and forehead, with precious ointments and tonics. The anecdote of that famous legislator, who to restrain the intemperance of the people, authorized it by an express law, is well known; and we read that Lycurgus caused drunken people to be publicly exhibited, in order to excite a horror of intoxication in the Lacedæmonian youth. By a law of Carthage, the use of wine was prohibited in the time of war. Plato interdicted it to young persons below the age of twenty-two. Aristotle did the same to children and nurses. And we are informed by Palmarius, that the laws of Rome allowed to priests, or those employed in the sacrifices, but three small glasses of wine at their repasts.

But, notwithstanding the wisdom of

laws, the hideous picture of intemperance, and the fatal consequences with which it is attended, the attractions of wine have been so powerful among certain nations, that their fondness for it has degenerated into a passion, and real want. We daily see men, prudent in other respects, gradually acquire the habit of indulging immoderately, in the use of this liquor; and, in their wine, extinguish their moral faculties, and their physical strength.

The virtue of wine differs according to its age. New wine is flatulent, indigestible, and purgative: *mustum flatuosum et concoctu difficile. Unum in se bonum continet, quod alvum emolliat. Vinum rarum infrigidat; mustum crassi succi est, et frigidi.*

The antients confounded these words; *mustum et novum vinum.* Ovid says, *Qui nova musta bibant. Unde virgo musta dicta est pro intacta et novella.*

Light wines only can be drank, before they have grown old. The reason we have mentioned, in the preceding pages. The Romans, as we have observed, followed this custom, and drank their wines in succession: *Vinum Gauranum et Albanum, et quœ in Sabinis et in Tuscis nascuntur, et Amienum quod circa Neapolim vicinis collibus gignitur.*

New wines are not all nourishing, especially those which are aqueous, and little saccharine: *corpori alimentum suggerunt paucissimum,* says Galen.

These wines readily produce intoxication; and the reason of this is, the quantity of carbonic acid with which they are charged. This acid, by disengaging itself from the liquor by the temperature of the stomach, extinguishes the irritability of the organs, and brings on stupor.

Old wines, in general, are tonic, and very wholesome; they are suited to weak stomachs, old people, and in all cases where strengthening is necessary: they afford very little nourishment, because they are deprived of their really nourishing principles, and any other than alcohol.

Oily thick wines are the most nourishing. *Pinguia sanguinem augent et nutriunt;* Galen. The same author recommends the wines of Therea and Scibellia as highly nourishing: *quod crassum utrumque, nigrum et dulce.*

Wines differ also essentially in regard to colour. Red, in general, is more spirituous, lighter, and more digestible: white wine furnishes less alcohol, and is more diuretic and weaker, and has remained less time in the vat: it is almost always more oily, more nutritive, and more gaseous, than the red.

Pliny admits four shades, in the colour of wines: *album, fulvum, sanguineum, rubrum:* but it would be too minute as well as useless to multiply shades, which might become infinite, by extending them from black to white.

Climate, culture, and variety, in the processes of fermentation, produce also infinite differences in the qualities and virtues of wine. To avoid repetitions, we must refer to what we have already said on this subject

The art of tempering wine, by the addition of one part of water, was practised among the antients: wine of this kind they called *vinum dilutum.* Pliny, after Homer, speaks of a wine, which could bear 20 parts of water. The same historian informs us, that in his time, wines so spirituous were known, that they could not be drunk: *nisi pervincerentur aqua et attenuarentur aqua calida.*

The antients, who had very just and correct ideas, respecting the art of making and preserving wines, seem to have been unacquainted with that of distilling spirit from them. the first correct ideas respecting the distillation of wine, are ascribed to Arnaud de Villeneuve, professor of medicine at Montpellier.

WIPERS OF STAMPERS. See Mechanics. See also Weaving by Power Looms.

WIRE. See Iron, and Manufacture of Iron.

WOAD. On the cultivation and manufacture of, in a letter to the Bath and West of England Agricultural Society, by Mr. John Parrish.

Woad is a plant which, combined with indigo, gives the best and most permanent blue dye hitherto discovered.

This plant is cultivated in different parts of England for the use of the dyers, as well as in France, Germany, &c. It is best to sow the seeds in the month of March, or early in April, if the season invite, and the soil be in condition to receive it; but it requires a deep loamy soil, and is better still with a clay bottom, such as is not subject to become dry too quickly. It must never be flooded, but situated so as to drain its surface, that it may not be poisoned by any water stagnant upon it.

If (at any reasonable price) meadow land to break the turf can be obtained, it will be doubly productive. This land is generally freest from weeds and putrid matter, though sometimes it abounds with botts, grubs, and snails. However, it

saves much expense in weeding; and judicious management will get rid of these otherwise destructive vermin. A season of warm showers, not too dry or too wet, gives the most regular crop, and produces the best woad.

If woad is sown on corn land, much expense generally attends hoeing and weeding; and here it will require strong manure, though on leys it is seldom much necessary, yet land cannot be too rich for woad. On rich land, dung should be avoided, particularly on leys, to avoid weeds. Some people sow it as grain, and harrow it in, and afterwards hoe it as turnips, leaving the plants at a distance, in proportion to the strength of the land; others sow it in ranks by a drill-plough; and some dibble it in, (in quincunx form, by a stick, with a peg crossways, about two or two and a half inches from the point, according to the land) putting three or four seeds in a hole, and these holes to be from twenty inches to two feet apart, according to the richness of the land; for good land, if room be given, will produce very luxuriant plants in good seasons; but if too nearly planted, so that air cannot circulate, they do not thrive so well. Attention to this is necessary in every way of sowing it. Woad very often fails in its crop, from the land not being in condition, or from want of knowing how to destroy the botts, snails, wire worms &c. that so often prey upon, and destroy it, as well as from inattention to weeding, &c. Crops fail also from being sown on land that is naturally too dry, and in a dry season; but as the roots take a perpendicular direction, and run deep, such land as I have described (with proper attention to my observations) will seldom fail of a crop; and if the season will admit sowing early enough, to have the plants strong before the hot and dry weather comes on, there will be almost a certainty of a great produce.

These plants are frequently destroyed in the germination by flies, or animalculæ, and by grubs, snails, &c. as before observed; and in order to preserve them, the seeds may be steeped with good success, in lime and soot, until they begin to vegetate; first throwing half a load or more of flour lime on the acre, and harrowing it in. Then plant the seeds as soon as they break the pod, taking care not to have more than one day's seed ready; for it is better to be too early, than to have their vegetation too strong before it is planted, lest they should receive injury; yet I have never observed any injury in mine from this, though I have often seen the shoot strong. Either harrows or rollers will close the holes. If the ground be moist it will appear in a few days; but it will be safe, and a benefit to the land, to throw more lime on the surface, when, if it showers invite snails and grubs to eat it, they will be destroyed, which I have several times found; particularly once, when the leaves were two inches long, and in drills very thick and strong, but the ground was dry. When a warm rain fell, in less than two hours I found the ranks on one side attacked by these vermin, and eaten entirely off by a large black grub, thousands of which were on the leaves, and they cleared as they went, not going on until they had destroyed every leaf where they fixed. They had eaten six or seven ranks before I was called by one of my people to observe it. Having plenty of lime, I immediately ordered it in flour to be strewed along those ranks which were not begun. This destroyed them in vast numbers, and secured the remainder. Another time, having had two succeeding crops on four acres of land, I considered it imprudent to venture another. However, as the land after this appeared so clean and rich, I again ventured, but soon found my error. On examining the roots (for after it had begun to vegetate strong, it was observed to decay and wither) I found thousands of the wire worm at them, entwined in every root. I immediately strewed lime, (four loads of six quarters each, on the four acres) and harrowed it; when rain coming on soon after, washed it in, and destroyed them all, and gave me an extraordinary crop; but the first sown side of the field, where they had begun, never quite recovered like the rest. And I am fully satisfied, that when the grub is seen in wheat, &c. the same treatment (if the weather suited) would destroy them all, as well as change the nature of the land. I need not enter on the wide and extensive field of observations on the causes of weeds, grubs, &c. (which so often counteract the labours of the husbandman) that occur so differently in different seasons, and after different treatment and improper crops—further to observe, that when your land has not a proper change, then it is that these are experienced in a more destructive degree.

Further, it is in vain to expect a good crop of woad, of a good quality, from poor and shallow land. The difference of produce and its value is so great that no one of any experience will waste his labour and attention on such lands, upon so uncertain a produce. Warm and moist

seasons increase the quantity every where, but they can never give the principle which only good land affords.

In very wet seasons, woad from poor land is of very little value. I once had occasion to purchase at such a time, and found that there was no possibility of regulating my vats in their fermentation; and I was under the necessity of making every possible effort to obtain some that was the produce of a more congenial season. I succeeded at last; but I kept the other, three and four years, when I found it more steady in its fermentation; but still it required a double quantity, and even then its effects was not like that from good woad.

The leaves of woad on good land, in a good season, grow very large and long, and when they are ripe show near their end a brownish spot, inclining to a purple, towards its centre, while other parts of the leaves appear green, but just beginning to turn of a more yellowing shade; and then they must be gathered, or they will be injured.

Woad is to be gathered from twice to four, and even five times in the season, as I once experienced, (It was an early and a late season) and for the next spring I saved an acre for seed, of which I had a fair crop. I picked the young seedling sprouts off the rest, and mixed with my first gathering of what was newly sown; this was very good. During one season I let these shoots grow too long; the consequence was, that the fibrous parts became like so many sticks, and afforded no saponaceous juices. When you design to plant woad, on the same land the second season, it should be as soon as your last gathering (before winter is finished) be ploughed; that is, as soon as the weather will permit, and in deep furrows or ridges, to expose and ameliorate it by the vegetative salts that exist in the atmosphere, and by frost and snow. This, in some seasons, has partly the effect of a change of produce; but if intended for wheat, the last gathering should not be later than September.

The land, after woad, is always clean, and the nature of the soil appears to be greatly changed in favour of the wheat crop: for I have always experienced abundant increase of produce after woad, and observed that it held on for some time, if proper changes were attended to and good husbandry. Keeping land clean from weeds, certainly produces an increase of corn; but in the hoeing and gathering woad, (for hoeing and earthing up the plants often renders them abundantly more prolific, even if there are no weeds) many nests of animaculæ are destroyed, as well as grubs and insects, which are destructive to vegetation.

Woad when gathered, is carried to the mill and ground.

These mills grind or cut the leaves small, and then they are cast into heaps, where they ferment, and gain an adhesive consistence; they are then formed into balls, as compact as possible, and placed on hurdles, lying horizontally in a shed, one over the other, with room for air between, to receive from the atmospheric air, a principle which is said to improve them as a dye, as well as to dry them to a degree proper for being fermented; but in summer these balls are apt to crack in drying, and become fly-blown, when thousands of a peculiar maggot generate, and eat, or destroy all that is useful to the dyer. Therefore they require attention as soon as any are observed to crack, to look them all over well, close them again, so as to render them as compact and solid as possible; and if the maggot or worm has already generated, some fine flour lime strewed over it will destroy them, and be of much service in the fermentation. These balls, if properly preserved, will be very heavy; but if worm-eaten, they will be very light, and of little value. They are then to be replaced on the hurdles, and turned, not being suffered to touch each other, until a month or more after the whole that is intended for one fermenting couch, is gathered in, ground and balled, and often, until the hot weather of summer is past, to render the offensive operation of turning it, less disagreeable, and not so apt to overheat; and though temperature herein is necessary, yet a certain degree of heat must be attained, before it is in a proper condition for the dyer's use. This is easily distinguished by a change of smell—from that which is most putrid, and offensive, to one which is more agreeable and sweet,(if I may be allowed the term) for few people at first, either can approve of the smell of woad, or a woad vat; though, when in condition, they become quite agreeable to those whose business it is to attend them. Woad is in this state of fermentation, more or less time, according to the season and the degree of heat it is suffered to attain, whether at an early period, or according to the opinion of those who attend the process; but the best woad is produced from a heat temperately brought forward in the couch until at maturity, and turned, (on every occasion necessary) which a proper degree of attention will soon discover.

These balls, when dry, are very hard

and compact, and require to be broken with a mallet, and put into a heap, and watered to a due degree, only sufficient to promote fermentation, but not by too much moisture, which would retard it; and here is a crisis necessary to be attended to. When the couch has attained its due point, it is opened, spread, and turned, until regularly cooled, and then it is considered in condition for sale; but the immediate use of woad, new from the couch, is not advised by dyers who are experienced; for new woad is not so regular in its fermentation in the blue vat. This is the common process. Woad oftentimes is spoiled herein, by people who know nothing of the principles of its dye, following only their accustomed process of preparing it; and hence the difference in its quality is as often seen, as it is in the real richness or poverty of the leaves, from the quality of the land. The process for preparing woad which I have followed, and which I consider beyond all comparison best, is as follows:

Gather the leaves, put them to dry, and turn them, so as not to let them heat, and so be reduced to a paste; which, in fine weather, children can do. In wet weather, my method was to carry them to my stove, and when I had got a quantity sufficiently dry, I proceeded to the couch, and there put them in a large heap; where, if not too dry, they would soon begin to ferment and heat. If too wet, they would rot, but not properly ferment, nor readily become in condition for the dyer. These leaves not having been ground, nor placed in balls on the hurdles, their fermenting quality was more active, and required more attention; and also the application of lime occasionally to regulate the process with the same kind of judgment as used in the blue dying woad vat. When the heat increases too rapidly, turning is indespensably necessary, and the application of very fine flour lime, regularly strewed over every laying of them; or, if the couch is getting too dry, lime-water, instead of common water, applied by a gardener's watering-pot, may have an equal effect, without loading the woad with the gross matter of the lime; though I conceive that the gross dry flour lime, and the oxygen in the air, will furnish more carbonic acid gas to the woad, and retain such principles as are essential, to a better effect. For I have experienced, that woad which requires the most lime to preserve a temperate degree of fermentation, and takes the most time, is best; so that at length it comes to that heat which is indispensably to the production of good woad.

In this couch it is always particularly necessary to secure the surface as soon as the leaves begin to be reduced to a paste, by rendering it as smooth as possible, and free from cracks. This prevents the escape of much carbonic acid gas, (which is furnished by the lime and the fermentation) and also preserves it from the fly, maggots, and worms, which often are seen in those parts where the heat is not so great, or the lime in sufficient quantity to destroy them. It is surprising to observe what a degree of heat they will bear. This attention to rendering the surface of the couch even and compact, is equally necessary in either process, and to turning the woad exactly as a dung-heap, digging perpendicularly to the bottom. The couching-house should have an even floor, of stone or brick, and the walls the same; and every part of the couch of woad should be beaten with the shovel, and trodden, to render it as compact as possible.

The grower of woad should erect a long shed in the centre of his land, facing the south, the ground lying on a descent, so as to admit the sun to the back part; and here the woad should be put down as gathered, and spread thin at one end, keeping children to turn it towards the other end. In the course of a week, every days gathering will be dry for the couch, which should be at the other end; therefore it will be necessary to calculate how long the shed should be; but this can be erected as you gather, and then it will soon be known.

Good woad, such as the richest land produces, if properly prepared, will be of a blackish green, and mouldy; and when small lumps are pulled asunder, the fracture and fibres are brown; and these fibres will draw apart like small threads, and the more stringy they are, and the darker the external appearance, and on the green hue, the better the woad; but poor land produces it of a light brownish green. The fibres only serve to show that it has not suffered by putrefaction.

For the use of the dyer, the balls require a farther preparation. They are beaten with wooden mallets, on a brick or stone floor, into a gross powder, which is heaped up in the middle of the room, to the height of four feet, a space being left for passing round the sides. The powder moistened with water, ferments, grows hot, and throws out a thick fetid fume. It is shovelled backward and forward, and moistened every day for twelve days; after which it is stirred less frequently, without watering, and at length made into a heap for the dyer.

WOLFRAM. See TUNGSTEN.

WOOD, *staining of.* See DYEING.

WOOD, *preservation of.*

Various means have been used, in order to preserve wood work from decay. Dr. Parry has written an ingenious essay on this subject, which may be found copied into Mease's Archives of Useful Knowledge, and Coxe's Emporium. It is not our intention, to notice the causes which produce the decomposition of vegetable substance, and undoubtedly air and water are the primary ones, we shall state in general terms, the means which have been adopted, in order to prevent their access, for the preservation of the wood.

1. If paint be applied in several successive coats, it will have the effect of preserving the wood thus coated for years. In the use of paint, the oil as well as the pigment, tends to produce the effect.

2 *Oils.* Drying oil and other unctuous substances. These prevent the access of air and moisture very considerably.

3. The mixture of fine sand with white paint. This is said to be a good composition.

4. For water-shoots in particular, rubbing the surface with linseed oil, and pledging it all over with a thick layer of charcoal finely powdered, and contained in a muslin bag. After the oil is dry, rub off the superfluous coal, and apply a coat of white lead paint. In the place of powdered charcoal, lamp-black may be used.

5. Pitch, if applied hot, makes a good varnish or covering. Its mixture with Spanish brown, is said to answer a better purpose. The pitch, however, will be apt to run, if the wood work be exposed to the sun. The ends of posts, which are put in the ground, will be preserved by this substance.

6. A mixture of animal oils with bees wax, resin, and brimstone—melt twelve ounces of resin in an iron pot or kettle; add three gallons of train oil, and three or four rolls of brimstone melted and become thin, add as much Spanish brown, or red or yellow ochre, or any colour you want, first ground fine with some of the oil, as will give the whole as deep a shade as you like. Then lay it on with a brush as hot, and as thin as you can. Some days after the first coat is dried, give it a second. It will preserve plank for ages, and keep the weather from driving through brick-work.

These compositions are equally efficacious, in keeping iron from decay by rusting. They might also be very advantageously employed, in rendering water-tight, the plaister which is used, to case the outside of the arches of vaults, unsheltered by roofs, provided the mortar were made perfectly dry, and the covering of the arch brought up to an angle, instead of making it follow the form of the arch in an elipse or the segment of a circle.

Dr. Parry has given the following receipt for the preservation of wood.

Take twelve ounces of rosin, and eight ounces of roll brimstone, each coarsely powdered, and three gallons of train-oil. Heat them slowly, gradually adding four ounces of bees wax, cut into small bits. Frequently stir the liquor, which, as soon as the solid ingredients are dissolved, will be fit for use. What remains unused, will become solid on cooling, and may be remelted, on subsequent occasions

If the addition of charcoal, powder, or siliceous sand, contributes to the durability of drying oil, it may probably have a similar effect on the composition; but whether it may be best to mix them with the ingredients, or apply them afterwards, we cannot from experience tell. In the latter case, the powder should be sifted on, while the first coat of the composition is still hot; and after some days, when that is dry, should have a brush gently passed over it, in order to remove all the particles which do not adhere; after which other coats of the composition may be applied, as before directed.

7. The best preserver of wood is charcoal. For this purpose, it was the custom, and is now sometimes adopted, to char or carbonize the ends of posts, which are planted in the ground, to preserve them. The indistructability of charcoal, is well known.

8. Dr. Lewis advises all wood, that is exposed to the inclemency of the weather, to be coated with a preparation of pulverized pit-coal, and melted tar, reduced to the consistence of paint, which he has found very efficacious. In those cases, however, where piles or other masses of timber, are subject to the action of water, the most simple mode of preserving it, is that employed in the Bermuda Islands, and other parts of America. This plan has been stated, *to wit*, by applying whale or other animal oil.

9. To preserve boards, scantling, &c. the following method is used. Lay the boards in a bed of sand, (contained in a case or shell of brick-work,) and heated by means of a furnace, built beneath. As

soon as the wood becomes hot, the sap exudes, and is imbibed by the sand; in consequence of which, the quality of the timber is greatly improved. The boards will then last a considerable time.

10 In March 1778, a patent was granted to Mr. Humphrey Jackson, for his method of beautifying, and preserving the colour of every kind of wood, by means of a stain, varnish, and powder. He directs the substance first to be polished with the following composition.

Take pumice-stone and burnt alum, of each equal parts; lapis calaminaris, and green vitriol calcined to redness, of each half; let the whole be reduced to a fine powder, and rubbed with a woollen cloth on the wood, till it acquire a fine polish; the stain must now be prepared as follows.

Let six pounds of stick-lac, be boiled in three gallons of water, till the colour be extracted, when the liquor ought to be strained; half a pound of madder-root, is also to be boiled in three quarts of water: next, half a pound of cochineal, a similar quantity of kermes, and four ounces of clean scarlet-rags, are to be digested in a glass vessel, containing one gallon of spirit of wine, and a solution of two ounces of pearl-ash, in half a pint of water, till all the tinging matter be combined with the liquor. After straining it, the decoction of stick-lac must be added, and a sufficient quantity of aqua-fortis, be mixed with the whole, to impart a proper red colour; when the compound may be laid on with a brush. In order to prepare the varnish, the patentee directs one pound of clear white amber, half a pound of copal, a similar quantity of spirit of turpentine, as well as of the oils of rosemary, and lavender; and six pounds of nut-oil, to be digested in a sand-heat, till the oils acquire the consistence of syrup: the liquor is now to be strained for use; and, when the varnish becomes clear, it must be applied to the stained wood, with a painter's brush; after which it should be suffered to dry.

WOOL. The late importation of Spanish sheep into the United States, under the general name of *Merinos*, affording reasonable grounds for the belief, that the article of wool, so necessary to the health and comfort of man, will become a staple of our country, we think proper under this head to introduce some remarks upon this important article, which we hope and believe, will be found of importance, to all who are concerned in the various branches of manufacture, to which wool is appropriated. And first, from "Nicholson's Chemical Dictionary," we have extracted the following short, but pertinent treatise.

The principal differences in wool, consists in the length and fineness of its filaments. That which has the finest filaments, is reserved for fine cloths. The most beautiful wool, is brought to us, from Spain. It is said that the highland wool of Scotland, is equal in quality to this. Mr. d'Aubenton has shown, that it may be produced in France, of a quality not inferior to that of Spain; by folding the sheep through the whole year, and choosing the rams with care. Lately the breed of Merino, or fine woolled Spanish sheep, has been introduced into this country by his majesty, and found to retain the excellent qualities of the fleece. It has likewise been crossed with our own breeds with advantage, so that we may hope to become independent of Spain for fine wool.

Simple inspection may easily lead to error, respecting the fineness of wool, which it is important the manufacturer should know with accuracy; and Mr. d'Aubenton has proposed a method, of attaining this accuracy, by employing a micrometer, for comparing, by means of a microscope, the fineness of the wool to be examined, with that of other wools, chosen as standards.

Though the long wool is not so fine as the Spanish, and cannot be employed for fine cloths, it is still very useful for a variety of fabrics; and as the sheep which produce it, have much larger fleeces, the profit they bring, is not inferior to that of the fine woolled sheep; besides, the cloths made of their wool, being cheaper, have a much more extensive sale. The prosperous state of the woollen manufactures of England, is partly owing to our abundance of this wool. But the breed of sheep, which produces one or the other kind of wool, is connected with the nature of their pasture, which ought to determine us in the choice of them.

Wool is naturally covered with a kind of grease, which preserves it from moths. Reaumur has observed, that a stuff may be preserved from these insects, by rubbing it with greasy wool. Hence wool is not scoured, till it is about to be dyed or spun.

In order to scour wool, it is put for about a quarter of an hour into a kettle, containing a sufficient quantity of water, mixed with a fourth of putrid urine, heated to such a degree, as the hand can just bear, and it is stirred from time to time with sticks; it is then taken out and put to drain: it is next carried in a large basket to a stream of running water, where it is

moved about, till the grease is entirely separated, and no longer renders the water turbid ; it is then taken out and left to drain. It sometimes loses in this operation, more than a third of its weight.— The scouring should be carefully performed, because the wool is thereby better fitted to receive the dye.

The ammonia or volatile alkali, formed in putrid urine, has been supposed to unite with the grease, producing a kind of soap, which is soluble in water. But Vauquelin thinks, if any thing in the urine have an effect upon the grease or yolk, as the French call it, it is the uree. Fresh urine will not answer, on account of the acid it contains. According to him, soapsuds are the best menstruum for scouring wool, after simple water has washed off all it can remove. He observes too, that wool kept too long in its grease, swells, splits, and is weakened

The wool is dyed in the fleece, or before it is spun, chiefly when it is intended to form cloths of mixed colours ; or else it is dyed after being spun, and it is then intended principally for tapestry ; but it is sometimes dyed, after having been wrought into cloth.

When wool is dyed in the fleece, its filaments being separate, absorb a larger quantity of the colouring particles, than when it is spun ; for the same reason woollen yarn, takes up more than cloth ; but cloths themselves vary considerably in this respect, according to their degree of fineness, or the closeness of their texture : besides, the variety in their dimensions, the different qualities of the ingredients employed in dyeing, and a difference of circumstances in the process, prevent us from relying upon the precise quantities we find recommended for the processes described. This consideration may be extended to all dyes.

For most colours, wool requires to be prepared by a bath, in which it is boiled with saline substances, principally with alum and tartar : but there are some dyes for which the wool does not require such a preparation ; then it must be well washed in warm water, or wrung out, or left to drain. This is a general rule, which should be observed, with respect to all the substances intended to be dyed, in order that the colour may penetrate them more easily, and be distributed more uniformly.

Mr. Monge has explained the operation of felting, and the effects of fulling, by the external conformation of the wool and hair of animals. He has made some curious observations on this subject, of which the following are the chief:

Nothing particular can be discovered, by means of the microscope, in the filaments of wool, or in the hair of animals ; yet the surfaces of these bodies are not smooth : they must be formed, either of small laminæ, placed over each other in a slanting direction, from the root towards the point, like the scales of fish, which cover each other, from the head of the animal to the tail, or more probably, perhaps, of zones, placed one upon another, as we see in the horns of animals.

If a hair be laid hold off by the root, in one hand, and drawn between the fingers of the other, from the root towards the point, scarce any friction or resistance is perceived, and no noise is heard ; but if, grasping it by the point, it is passed in the same manner between the fingers of the other hand, from the point towards the root, a resistance is felt, which did not take place in the former place, and a tremulous motion is perceptible to the touch, and a noise sensible to the ear.

We perceive then, that the texture of the surface of hair, is not the same from the root towards the point, as it is from the point towards the root, and that a hair when pressed, must meet with greater resistance, in sliding or moving towards the point than towards the root ; but as it is this texture itself, which forms the principal subject of Mr. Monge's memoir, it is necessary to confirm it by some farther observations.

If, after having laid hold of a hair between the thumb and fore-finger, we rub them against each other in the longitudinal direction of the hair, it acquires a progressive motion, in that direction towards the root. This effect depends neither on the nature of the skin of the finger, nor on its texture ; for if the hair be turned, so that the point shall be placed, where the root was before, its motion will now be in an opposite direction, that is, it will still be towards the root.

These observations, to which Mr. Monge adds some others, are related of human hair, taken as an example ; but they are equally applicable to the filaments of wool, to horse-hair, and to that of animals in general. The surface of all these bodies, then is formed of rigid laminæ, laid upon each other like tiles, from the root to the point, which allow a progressive motion in the direction of the root, but oppose one in the direction of the point.

This structure is the principal cause of the disposition to felting, which the hair of animals generally possesses : the hatter, by striking the flocculi of wool, with the string of his bow, detaches and disperses in the air each of the filaments separately ;

these fall back one upon another in all directions on the table, where they form a layer of a certain thickness: the workman then covers them with a cloth (I suppose linen,) upon which he presses on all parts, with his hands extended.

The pressure brings the filaments of wool nearer to each other, and multiplies the points of contact; the agitation gives each of them a progressive motion in the direction of its root, by means of which they entangle each other; and the laminæ of each filament, taking hold of those of the other filaments, which are in an opposite direction, the whole is retained in the state of close contexture, which it had acquired by the pressure.

In proportion as the texture becomes closer, the pressure of the hands ought to be increased, both in order to make it still more compact, and to keep up the progressive motion, and intermixture of the filaments, which now meet with greater resistance: but during the whole of this operation, the filaments of wool lay hold of each other only, and not of the cloth, the fibres of which, as has been already observed, are smooth, and have not the same properties in this respect.

The aptitude for felting in wool and hair, does not depend entirely on the structure of their surface; it is not enough, that each filament should have a progressive motion, in the direction of its root; nor that the inclined laminæ, by laying hold of each other, should retain the contexture in the state, to which it has been reduced by compression: it is also necessary, that the filaments should not be straight like needles; for, by a continuance of the motion and pressure, each of them would continue its course progressively, without changing its direction, and the effect of the operation would be to remove them all from the centre, without producing any contexture. It is therefore necessary, that each filament should be crooked, so that the extremity nearest the root, should be so disposed to change its direction continually, to entwine itself round fresh filaments, and to return back upon itself, if it should be so determined by any change in the position, of the rest of its length.

Wool possessing this structure naturally, is peculiarly fitted for this kind of work, and may be employed in it, without being subjected to any previous preparation; but the furs of the rabbits, hares, and beavers, are naturally straight, and cannot be employed alone for felting, without having undergone a previous operation, which consists in rubbing them, before they are stripped, with a brush moistened with a solution of mercury in nitrous acid; this liquor, by acting only on one side of the hairs, changes their rectilinear direction, and communicates to them that disposition for felting, which wool naturally possesses.

The operation of fulling woollen stuffs, depends on the same property as felting.

The asperity of the surface of the filaments of wool, and their disposition to acquire a progressive motion in the direction of the root, form an obstacle to the spinning of wool, and the working it into stuffs. All the filaments must therefore, be covered with a coat of oil, which, by filling the cavities, renders the asperities less sensible; just as a coat of oil renders a fine file still smoother. When the piece of stuff is wrought, it must be freed from that oil, which gives it a disagreeable smell, renders it dirty, and would prevent it from taking the colour we wish to dye it; for this purpose, it is taken to the fulling-mill, where it is beaten with large beetles in a trough of water, through which some clay has been diffused. The clay uniting with the oil, renders it soluble in the water, and both are carried off together, by fresh water brought thither by the machine; and after sometime, the stuff is found clean scoured. See Earth (Fuller's.)

But scouring is not the only object in fulling; the alternate pressure of the beetles on the stuff, particularly when the scouring is advanced, produces an effect analogous to that of the pressure of the hatter's hands; the filaments of wool, which compose a thread of the warp, or of the woof acquire a progressive motion, insinuate themselves into the adjoining threads, then into those which are next, and presently all the threads, both of the warp and woof, are felted together. The stuff is now found contracted in length and breadth, and participates both of the nature of cloth, and of felt; it may be cut without being subject to ravel, and there is no necessity, for hemming the different pieces of it employed, to make a garment. If it be common woollen stocking web, the stiches are now no longer subject to run, when one of them happens to slip; finally, the threads of the warp and the woof, are now no longer so well defined, or so distinct from each other; and the stuff being also thickened forms a warmer clothing.

Berthollet obtained a large proportion of acid of sugar, by abstraction of nitric acid from wool

If wool be boiled with pure weak alkali, it is dissolved, with the escape of ammo.

nia, and forms a soap, likely to be of use in the arts. See Soap of Wool.

Mr. Tessier, a French writer of great merit, makes the following observations on the fleeces of wool, and of the different modes of washing them.

Wool should be kept in a place, which is neither damp nor dry. In a damp place it would grow heavier, to the disadvantage of the purchaser; in too dry a place, it would lose part of its weight, which would be unfavourable to the vender.—To keep it well, it should be placed in a lower room, that is exposed to the north, and cool, three or four feet from the ground, and not touching the walls. No dust should enter this place, otherwise the wool must be covered with linen.

Of the Fleeces and Wool.

The fleeces of merino rams which come from Spain, weigh at most, unwashed, eight pounds, and those of the ewes, five pounds; and in France we obtain from rams of that race, as much as 18 pounds, and from ewes as much as 12 pounds, this is the maximum. The usual weight for ewes, is from 7 to 8 pounds, and for rams, from 8 to 10 pounds.

What is the reason of the difference, between the weight of the fleeces of merinos, in Spain and in France? It is because in Spain, sheep live only upon what they find in the fields; sometimes they find very little there: besides, as they are of a smaller size, they must carry less wool. In France, the deficiency of pasture, is always amply supplied in the stable.

The weight of wool does not depend upon its thickness alone, but also upon its length: in this latter respect, we have gained much; our wool has become more fit for the manufacture of casimirs.

All parts of a fleece are not alike; it may be distinguished into wool of four different qualities: the first grows upon the shoulders and the back, from the neck to about half a foot from the tail, including a third part of the body; the second covers the sides, and extends from the thighs to the shoulders, approaching to the neck; the third grows about the neck, and covers the buttocks; the fourth covers, 1. from the fore part of the neck, to the extremities of the feet, comprehending a part of the shoulders, 2. the two hind-legs to the hoofs: in Spain, this fourth sort is called *cayda*, and in France *basse laine*. The more equal in quality, the wool is on all parts of the body, the greater is the value of the animal, which carries it. See Manufacture of Cloth.

Experiments which have been made in the garden of the Museum of natural history, by covering with linen cloth, during a year, the bodies of some wethers, have proved that wool, when protected from the air, grows finer and whiter: the difference is very sensible. But it remains to be determined, whether the expense of covering them, does not more than counterbalance the increased value of the wool; any person may easily make the calculation.

The wool of dead or sick sheep, should be put by itself, as being less fit for manufacturing, than that of healthy animals. I suspect it is more liable to be attacked by vermin; Mr. Roard has proved by experiment, that in dyeing, it does not take colour so well. Of three kinds of wool which I gave him, one from healthy sheep, another from sick sheep, and a third from dead sheep, the first took a deep dye from the different colours with which it was tried; the second took them faintly; and the third more faintly still. It follows, that proprietors of sheep should be careful, not to mix these different kinds of wool, and that manufacturers, would do well to show particular favour, towards those who do not deceive them.—I also think, that the wool of sheep killed in the slaughter-houses, which is taken off by means of lime, is much inferior to that of sheep shorn, while they are alive. It wants that oily matter, which nourishes it during the animal's life, and which continues in the wool, if it be shorn while the sheep is in full health; which is not astonishing, since the same thing may be observed, with regard to hair. Lime also renders the wool hard.

With a view of obtaining fleeces, both fine and long, sheep at Rambouillet have been suffered to go without shearing, two, three, four and five years. These animals bore their burden without appearing to be much incommoded by it; only they could not get up again if they happened to fall upon their sides, especially during the third year, for they carried a weight of from 24 to 30 pounds. After three years, the wool began to come out, and its quantity continued to decrease; none of them fell sick, after the fleeces were taken off. The manufactures, every year, purchase, with eagerness, and at a great price, these noble fleeces; it is not yet known to what use they apply them. I advise proprietors who wish to try this method, to do it with wethers rather than ewes, because the length of the wool is

troublesome to ewes, when they give suck.

Daubenton, in order to distinguish the different degrees of fineness in wool, makes use of a micrometer. But this instrument, though it affords the surest method, is troublesome for farmers, who do not know how to make use of it. Habit teaches them to distinguish the different kinds of wool, by simply comparing them together, or by laying them upon paper or black cloth.

Another observation, for which I am indebted to Mr. Roard, is that wool of different breeds does not all take dye equally well. Merino wool takes the deepest colour.

Wool may be kept longer if the yoke remain in it, than if it be washed; this oily substance keeps off a long time the insects which are apt to attack it. By placing it in the manner which I have before described, it will be still less exposed to vermin.

Wool is liable to be destroyed by several kinds of moths or caterpillars; (*tinea pellionella, tinea topezella, tinea vestinella, tinea sarcitella*) the butterflies which produce them, flutter about places in which wool or woolen goods are kept, from the months of April to the months of October; that is, almost from spring to winter, with some variation, according as the season is more or less warm. During all that time they deposit upon the wool little eggs, which can scarcely be perceived; from these eggs are produced the caterpillars; they are hatched in October, November, and December; they grow slowly at first, and become stiff when the weather is cold. In March and April they grow more; at that period they cut off many filaments, with which to nourish and cover themselves. They afterwards form a sort of sheath in which they gradually envelope themselves; when they are entirely sheathed, they are in the chrysalis state. At the end of three weeks, they change to butterflies.

There are three ways of discovering when wool is attacked by these insects: at first, butterflies of a bright yellowish colour, and three lines in length, are seen flitting about it: afterwards, are found upon the wool, little dry, angular grains, which appear grey if the wool is white, and blackish if it is black: lastly, along the walls and ceiling are perceived sheaths of a line in diameter, and four or five in length, a little swelled in the middle, and widened at the extremities.

It is difficult to guard effectually against these insects. The furriers beat with rods several times during the summer, the fur, and wool, which they have in their stores: the woolen drapers are careful to brush their cloths frequently; but these preventives would be ineffectual, if it were requisite to keep large quantities of wool. I know of no other than to place it as I have directed, taking care to kill all the butterflies which are found upon the walls, and to search for, and sweep down the sheaths. The penetrating substances which have been proposed are of no use.

Of Washing the Wool.

The wool, before it can be used, must be freed from a great proportion of that oily matter (in French called *suint*) with which it is impregnated, and be cleansed from all the filth which adheres to it. As the wool of merinos contains more grease than that of common breeds, and as it is shorter and more curled, it is usually dirtier, so much so, that a flock of merinos may be distinguished at a distance by this mark alone. Common wool is more easily cleared of its grease than the fine kinds; nothing more is requisite than to wash it in water which is a little warmed, or by being exposed to the heat of the atmosphere. If the sheep-houses are kept clean by frequently changing the litter, if the sheep are not led through dust, and if their folds are not upon a dusty soil, the fleeces are more profitable to the merchant or manufacturer who purchases them, because they lose less in washing. It is desirable that the proprietors of merinos attend habitually to the cleanliness of the fleeces, and particularly at the time of shearing, by preventing any dung from getting among the wool, of which manufacturers sometimes justly complain. And this should be attended to, not only from considerations of probity, but also that the manufacturers may have no pretext for beating down the price of the wool. But notwithstanding all the care of the proprietors, the fleeces become more or less dirty, and consequently lose more or less in weight, according to the nature of the soil on which the sheep are kept; so that it is best to wash the wool and put it nearly in the condition in which it is when sold by the Spaniards, or at least to clear it of the greatest part of its filth.

Many people endeavour to imitate the Spaniards; and, as is always the case, when a first attempt is made at a process which is not understood, the wool was but imperfectly washed, and cleared of its grease. The manufacturers complained of it; they said it was ill washed, knotty and brown; they preferred buying it

in the stste in which it was when taken from the animal. In which they were right; for Mr. Roard has remarked that when wool is imperfectly washed, it cannot be properly cleaned by a second operation. Latterly, people have in many places been more successful, notwithstanding what the manufacturers say, who, for the most part, being guided by interest, pretend to see no difference between what is well, or what is ill done. It must, however, be confessed that many people in France do not yet wash it well. If we can establish laundries, we shall be able to offer for sale wool like that which comes from Spain. All haggling between the owners of flocks, and manufacturers, will be prevented; the wool will be sold according to its quality. The expense of carriage, as has been already observed, will be saved, and no pretext will be left for purchasing at a low price. This is still wanting to complete our improvements, and to enable us to arrive at the end proposed in introducing merinos into France.

Above twenty years ago, I procured information in Spain upon this subject. I am also indebted for information to Mr. *Poyferé de Cére*, who has given me the plan of a laundry, drawn by himself upon the spot.

In France, wool cannot be well washed, except between the time of shearing and the end of October, because time is necessary to dry it.

The first operation is, to part the different qualities, that they may be washed separately. Practice teaches to distinguish the various sorts. After this, the wool is spread upon hurdles, tossed about and beaten with rods, in order to clear it as much as possible from dust and other dirt; all the dung, pitch, &c. must be picked out by hand; it is then combed with a little instrument that has short curved teeth, set far apart. This operation must precede every mode of washing.

I shall first give Gilbert's mode of washing wool, with the more confidence, as I found that it was followed in a famous manufactory at Louviers. The workmen may perhaps have concealed a part of their process from me; yet it is certain that the method I am about to explain, answers very well. I shall afterwards describe the method of washing on a great scale, brought by Mr. *Poyféré de Cére* from Spain, with the description and plan of the fine laundry at Alfaro.

Gilbert's Method.

"The fleeces are put into tubs or casks, or any other vessels of a capacity suited to the quantity of wool to be washed.—When they are filled with wool gently pressed down, but not trampled, water warmed to 30 or 40 degrees (of Reaumur, equal to 67 1-2, or 90 of Farenheit) is to be poured in gradually, till it covers the wool. The next morning, or at the end of twenty-four hours, the washing is to be begun; the soaking should not continue less than 18 hours. In order to avoid trouble, the tubs should be placed as near as possible to the place where the washing is performed. The water in which the wool is soaked becomes filled with grease; it is this water which is most necessary in the washing; and care should be taken not to waste it; some of it is to be poured into caldrons, and heated to 50 or 60 (112 1-2 or 135) degrees; a heat below 50 (112 1-2) degrees would not be sufficient; if above 60 (135) it would crisp the wool, and render it hard and brittle. The proper temperature may be determined without the aid of a thermometer; it should be just that at which the hands cannot be held in the water without scalding them.

"When the water is at this temperature, some wool is put into the cauldron: the less that is put in at a time, the more completely is the end answered. A smooth stick, or rather a smooth wooden fork, should be employed to stir the wool, which should be continually lifted up, in order to open it, and render it more permeable; if it were turned over, it would twist, and thus impede the subsequent operations. After having been immersed three or four minutes, it is to be taken out, either with the hands or with the fork; it is put into a basket, which is held a short time over the cauldron, to drain and to save the greasy water. As the water in the caldron diminishes, it must be replenished. If it become muddy, the caldron must be entirely emptied, and fresh water from the tubs poured in. The water is warm enough if the wool washes well; before taking it out of the caldron, it should be tried from time to time. It would be well if the place where this operation is performed was under cover: this cannot always be the case, for which reason fine weather should be chosen. When the wool is taken out of the caldrons, it is to be carried near the place where it is to be washed; baskets are made use of, for this purpose. It is not a matter of indifference what kind of water is used; the best is that which washes linen well, in which vegetables are soon cooked, which makes good soap-suds, and which is very good to drink; running

water is better than stagnant water; well water is the worst; if no other can be procured, it should be previously drawn and exposed to the air several days, or it should be boiled.

"To wash wool effectually in running water, two open wrought baskets should be placed in the stream, one higher up than the other, care being taken that the water does not rise to the top of the baskets, lest the wool be carried away. The washing is done in the lower basket, and the wool, when washed, is thrown into the one which is higher up; it there takes its last degree of purity Care should be taken not to rub the wool; it is sufficient to move it about rapidly in the water, and to open it as much as possible with the rake; it should be drawn continually from one part of the basket to another. As soon as the wool opens freely and floats on the surface like a cloud, and the water of the first basket becomes clear, it is taken out to dry.

"When the washing is performed in water that does not flow, baskets with two handles at the sides, are made use of, and are plunged repeatedly into the water, until it ceases to be fouled by the wool."

Gilbert, directs a press to be used, in order to squeeze the water out of the wool, or a compression produced by two strong men twisting a cloth into which the wool is put. This method, which does no injury to the wool, accelerates the drying of it, and is convenient when the season is far advanced A single fine day is afterwards sufficient.

A spot of short thick grass should be chosen, on which to dry the wool, unless there be a building constructed for the purpose. The place must be first cleaned and swept, so that no filth may adhere to the wool. It would be better to dry it upon hurdles or upon flint-stones.

According to Gilbert, merino wool well washed, and well dried, loses two-fifths of the weight which it had before washing; and according to our own observations, it loses three-fifths, or even fifty per cent.

In all the manufactories, a last washing is given to wool brought from Spain, which never comes thoroughly washed; it loses in this last operation from fifteen to twenty per cent. To the water in which the wool is soaked, urine and potash are added. According to Gilbert, these additions are useless. If the wool be soaked in warm water for eighteen or twenty-four hours, it preserves its flexibility and elasticity; and it is whiter than that which comes from Spain.

Method recommended by Mr. Girou de Buzaringues

A proprietor in the department of Aveyron, who has succeeded well in cleaning his merino wool, says that he soaked it twenty-four hours in cold water, to obtain the grease. I think that warm water would be preferable. Mr. Girou de Buzaringues advises, properly I think, to spread the fleeces, and to place them in tubs, with the outside of the fleeces uppermost, lest the pressure of the water, if they were placed otherwise, should render them impermeable. When, for the purpose of obtaining greasy water, he employs coarse wool, which is always dirtier, he strains the water. On these three points he differs from Gilbert, whose method, on the whole, he follows.

The methods recommended by Gilbert and Mr. Girou, may be practised by any body. Every one may wash his own wool, if he follow the directions given. It is only necessary to proportion the apparatus and water to the quantity of the wool to be washed.

Spanish Method.

In Spain, where numerous flocks belong to great proprietors, buildings have been erected for the purpose of washing wool, in which are at once united, economy of time and expense, and where the wool is cleansed sufficiently for the subsequent operations which it is to undergo in the manufactories. This was a subject worthy of inquiry. Mr. *de Poyfere de Cere* has afforded us every requisite information, by giving us an exact description of one of their fine laundries, of which he took a drawing upon the spot. It is that of Alfaro, where the wool of the Paular, Montarco, Turbietta, and other famous flocks, is carried every year to be prepared, at a small expense, and afterwards sold to foreigners.

The united waters of the Eresma, and other streams, which have their source in the mountains which separate Old from New Castille, flow towards Segovia, and thence into reservoirs or basins, at Alfaro.

"These reservoirs, says Mr. *de Poyfere*, contain above one hundred and fifty-eight thousand, nine hundred and four cubic feet of water; an immense resource, supplied by a constant stream, which serves to afford a temporary supply to the laundry, if at any time the stream becomes muddy and unfit for use.

"The water being admitted into the laundry, and the wool having been picked by hand, and separated into first, second, third qualities, and refuse, it is placed under a shed near to the vats.

"The vats are filled to two-thirds of their depth with hot water, by means of a cock communicating with a boiler. This water may be tempered at pleasure with cold water. A man is stationed to regulate it, which he does by putting his leg into each vat, and ordering hot or cold water to be added, as he sees proper, until the degree of heat is such that he can no longer endure it without being scalded. He then gives the signal for immersing the wool; the length of the immersion is regulated by the time requisite for emptying the second and third vats before returning to the first.

"A man descends into one of the vats, takes out a certain quantity of wool, and puts it into wicker baskets.

"Children, holding fast by lines, get upon the wool in the baskets, and tread it with their feet, to press out the greasy water with which it is charged. This water escapes through the drains of the grated-work, on which the baskets are placed, into a cistern, and empties itself out of the laundry.

"The wool thus pressed, is emptied out upon a grated-work. Three children take it up, divide it, and deposit it on the margin of one of the layers. A man (this is the principal hand) placed upon a flight of steps, takes the wool handful by handful, divides it again, and lets it fall into a canal.

"Two men are placed in a laver, resting their hands on a cross-piece, which is firmly fixed, who move their right and left leg alternatively, so as to drive back the water and separate the flocks of wool. The depth of the water in the laver is from 11 to 12 inches.

"Four men placed in the canal of the laver, resting their hands upon the sides of it, repeat the motions of the two men stationed in the basin.

Four other men, also standing in the canal, gather up the wool as it is carried along by the current of water. They make it up into bundles, without wringing or twisting it, press out the water, and throw the wool upon the floor A child takes it and deposits it on a shelving drainer. After passing through several hands, it is finally placed in a heap on the top of the drainer.

The wool is suffered to remain here during four and twenty hours. At the expiration of which time, it is carried to a neighbouring meadow, which has been raked and even swept with care, and there spread out in small parcels until it is quite dry, which commonly requires three or four days.

The wool which escapes the four men, placed in the canal, is carried by the stream into a wooden cage, whose bottom and sides are covered with a net that has very small meshes. Three men stationed in this cage, stir about the wool with their feet; and as they gather it up, they make it into small bundles which they press out with their hands, and which they throw upon the floor, where two children receive it in small baskets, squeeze it, and carry it to the great heap at the top of the drainer.

Such is the operation of washing, practised in Spain, for wool of the highest reputation. At Alfaro, the work begins at three o'clock in the morning, and does not end till night. In one working day, which is about sixteen hours, three hundred French quintals (antient measure) of wool are washed.

Method communicated by a Manufacturer of Montjoie.

A manufacturer of Montjoe, in the department of Roer, is of opinion, that proprietors of merino flocks, who are distant from manufactories, might advantageously confine themselves to a simple washing, so as to take off nearly all the filth, and to preserve grease sufficient for the washing at the manufactory. He directs the different sorts of wool, of which a fleece is composed, to be picked, and put separately into a basket; the wool to be placed in a stream of water, and taken out and plunged in again from time to time; to be stirred with a wooden rake; and when no more filth comes out, to be dried in the open air. According to him, fleeces thus cleaned do not lose in the washing at the manufactory more than thirty-three per cent, while that which is sold dirty, and with all its grease, may lose as much as seventy-five, if the animals have been ill taken care of, and kept in dusty places. This at least is certain, that having tried this method with a small quantity of my wool, a distinguished manufacturer of Verviers, who saw it, assured me that it would wash perfectly well at the manufactory, and that this was the state in which it answered best. If this assertion be true, as in all probability it is, nothing is easier than to give the wool a first preparation, which will diminish the expense of carriage, which may be effected by all proprietors of flocks in the neighbourhood of streams of water, and which will not prevent the last washing, indispensable before the wool is manufactured. If this method be pursued, the coarse and very dirty parts of the fleeces

should be excluded, such as the wool of the forehead, of the belly, the thighs and the legs. This mode of washing answers nearly to washing the wool upon the sheep's back, except that it cleanses it more effectually. If the manufacturers will be just enough to give a price for this wool, such as to compensate for its diminution in weight, and proportioned to what they would have given if they had bought it dirty and greasy, I do not doubt that many proprietors will adopt this method.

Washing at the Manufactory.

The washing at the manufactory is performed in the following manner. A caldron, capable of holding with ease from 30 to 40 kilogrammes of wool, is filled with a mixture of two-thirds water, and one-third urine, and is heated. When this liquid arrives at the temperature of from 40 to 45 degrees, (90 to 101 of Farenheit) so that the hand can bear it, the wool is put in, and left there half an hour, being stirred about continually with much care, by means of small wooden forks; it is then taken out and drained, then washed, in small parcels, in a river or brook, until it ceases to foul the water, and finally dried for use. In some manufactories, the mixtures made with three quarters water, and one quarter urine, which answers as well.

Private individuals who wish to wash small quantities of wool, in order to manufacture it at home, may employ Gilbert's method, or that recommended by the manufacturer of Montjoie; whichever be adopted, it must be succeeded by the wash with urine just mentioned. If no river nor rivulet be near at hand, baskets filled with wool may be plunged into tubs of clean water, which must be constantly renewed. This operation is indeed long; and I do not recommend it unless the quantity of wool is small.

Sale of Wool.

Two opposite interests meet in the sale of wool, that of the proprietor of the flock, and that of the manufacturer. If they deal by an intermediate agent, that is, by means of a merchant or a broker, a third interest arises, distinct from both. It is best for the manufacturer to purchase immediately from the proprietor: they thus save between them the profit which would have gone to the third person; but it is difficult to effect this. Those who raise flocks are not acquainted with the manufacturers, and have no way of applying to them; they are therefore obliged to wait until traders come to them; and thus they deal with none but merchants, who afterwards dispose of the wool to the manufacturers.

The manufacturers, however send their agents into the country to purchase wool at a low price, by persuading the country people that what they offer is the current price, and that it is for their advantage to accept their offers. The want of money, and the fear of losing by delay, induce them to sell at a low price. Some great proprietors of flocks, obtain better information; they learn the prices of wool in Spain, know the vents for manufactures, and, being less in haste, bring the manufacturers nearly to the just price.

It is customary to give four pounds of wool over and above every hundred; the manufacturers call this a gift. This custom is to the disadvantage of the vender; it would be better to make the bargains for a real and precise quantity, without any addition. This custom has arisen from the allowance which was formerly made for the weight of the bands. The manufacturers have since insisted upon the gift of four per cent, and an allowance for the bands besides. The proprietors of flocks should consent to neither of these reductions; the weight of the bands is nothing, if pack-thread or rushes be employed.

The vender derives an advantage from disposing of his wool immediately after shearing; because, in drying, the weight is diminished. It is also profitable to the purchaser, to obtain it as soon as possible after it is shorn, because it can be cleaned better, as it contains more grease; the season is besides more favourable for washing. If it be sold ready washed, the above advantages do not result from selling it at one time rather than at another.

Many French manufactories had contracts, for a certain number of years, with proprietors of flocks in Spain, for the purchase of their wool. It was usual for the latter to give credit. Nothing hinders similar borgains from being made in our own country. Flocks remarkable for the fineness of their wool, would undoubtedly find manufacturers desirous of securing it for themselves.

By experiments made with great care and exactness in 1807, which I myself witnessed, it is proved that the wool of French merinos is equally as strong and elastic as that of Spanish merinos. By an attentive comparison, it has been discovered that, when employed in manufactures, their products are strictly equal in quality and quantity; consequently, the price of French merino wool ought to be regulated by that of the Spanish merinos.

Mr. John Luccock, a celebrated English wool stapler, of Leeds, (Yorkshire) writes as follows on the essential qualities of wool:

"If the improvement of wool consist entirely in rendering it better adapted to manufactures, the growers very naturally ask, what are those properties which the workmen deem most valuable? what should be our definite and particular object when we attempt to cultivate the fleece? not possessing information upon the subject, we are liable they say, to great mistakes, and our wool may derive its worst qualities from the very measures which we thought best adapted to promote improvement. Too often our knowledge upon subjects of this nature, has been collected only from obscure hints, casually dropped by the buyers; some of whom we have suspected of being interested in deceiving us, and in a few instances have illiberally charged them with combining to defraud. In general these gentlemen, who we are sure must possess the most accurate knowledge both of wool and the manufacture, communicate information very sparingly, and seem afraid lest we, who alone possess the power of changing the qualities of the pile, should understand too much of its properties and its application. They often tell us that its value has decreased, because the demand for it has lessened; and yet we find no surplus of wool. We are assured that the articles into which our wool was wrought, have ceased to be made, and yet they appear desirous to purchase it; and when we have cultivated the qualities, which they once extolled, we almost invariably hear them reprobated as the most pernicious alterations. This inconsistency is too obvious to escape our notice, and the wool buyer must pardon us if we trace it to his caprice, or a design to mislead us.

Such are the complaints which the grazier utters almost every returning summer, such the charges which he seriously urges against the stapler. Many of them are totally void of foundation, and originate only in the want of better information, or in that suspicion in one party, which is always the offspring of ambiguous conduct in the other. Yet wherefore should ambiguity and suspicion subsist? Is it because the occupations of the wool grower and the stapler are incompatible with manly behaviour and generous principles? Or because long established prejudice has induced a habit of transacting business equally dishonourable to both parties? The author of these pages will deem himself happy, if by attempting to convey to the wool-grower some general information respecting the qualities of wool, he shall be able to quiet some of those bickerings which have long disgraced the transactions of the buyers and the sellers of an article constantly used. In describing them, he will prefer perspicuity to the ornaments of stile, and observe that order alone in which they occur to recollection.

That wool is evidently most distinguished for good qualities, which may be fabricated into a valuable article, by means of the implements in common use, in the most perfect manner, and with the smallest degree of labour and expense. It would be idle to enquire what would become the valuable qualities of the pile, if a change occurred in the taste of those who ultimately consume woolen goods, if those now in demand were to be no longer made, or if the implements of the manufacture were more perfectly constructed. The present state of the manufacture, of the implements, and the demand, must limit our enquiries.

When the fleeces are separated from the back of the sheep, they are invariably found to contain a variety of different kinds of wool, very frequently suitable to the fabrication of articles very dissimilar in their nature, and adapted to processes in the manufacture of a description totally different from each other. The chief business of the stapler is to separate the portions of this mingled mass, to distribute them in their proper order, and to supply the manufacturers with the peculiar kind of wool, required by the goods which each of them makes. This employment is very different from that which occupied the stapler's attention in the thirteenth and the two following centuries, when he was engaged only in exporting to a foreign market the fleeces of his country, almost, if not entirely, without assortment. At present, his occupation constitutes him the agent of the manufacturer, or rather in his hands, wool passes through the first stage of the process adopted to render it useful; and it becomes his business and his interest to watch the state of trade, to notice the changes in the demand for different articles, to remark the nature and qualities of the wool, and to point out to the grower the properties of the fleece, which are successively, of superior or of smaller importance. The art of sorting wool, almost unknown a few centuries ago, has been very considerably improved during the last hundred years; and as the division of labour, in most other branches of manufacture, contributed to their advancement, so in the fabrication of woolens it has produced very essential benefits. But some who are employed in sorting wool, situated far remote from the manufacturers,

and hearing none of their complaints, either have no precise object in view, or perform their work so ill as to render it necessary to incur a second expense for workmanship, or their sorts must pass into the market debased below their real value. Persons to whom this remark applies should always recollect, that in every intermixture of coarse and fine wool, it is impossible to prevent the first from forming the exterior of the thread and the surface of the piece, so that in all ill-performed sorting, only the worst portion of the wool becomes visible, when passing through the manufacturers hand.—This employment which Dr. Parry, who engaged a person to break some wool after the Spanish manner, complains of, requires much greater dexterity than is readily conceived, by those who have only seen it performed. Had a common workman merely torn the fleece across the loins, taken off the skirts, and divided the remainder into three parts, almost without indiscrimination, we also should have called it, "a lazy and artless operation;" and had we been charged the price for the workmanship, which the doctor paid, we should have expressed ourselves in terms, which we are always sorry to utter, and never wish to repeat.

This is the mode of sorting wool adopted in Spain; but the English workman, finds it contribute to his interest, to be scrupulous in the separation of the pile, and has introduced a much greater number of sections, into his method of breaking the fleece. In this country, there are three general kind of fleeces, and each of them is sorted in a manner different from the others. The finest includes all those adapted to the fabrication of woollen articles, and comprehends by far the larger proportion of the wool of the island; the second comprehends the longer pile, that which is suitable to worsted goods; and the other is confined to wool of a medium length, that which is used in the hose trade. The number of sorts, into which the fleeces of each class are divided, is always arbitrary; but custom has introduced an imperfect kind of system, to which most staplers conform. The number of sections adopted in the hose trade, is generally six or seven, and the names applied to them are only two, Drawing and Matching, but distinguished in the inferior divisions, by the epithets common, fine, blue, brown and super. The fleeces suitable to worsted goods, when considered upon a scale comprehending most of that kind of wool, produced in the kingdom, admit of about sixteen sorts, half of them obtained from the wool of sheep, which have been shorn more than once, and the others from hog fleeces.—Those who break the shorter wools, sometimes make about 17 different divisions in a pile of fleeces, and very few staplers, even those who purchase the inferior parcels of this description, reckon fewer than nine sorts; but manufacturers sometimes content themselves, with three or four distinctions. The names which in the east of the kingdom, are commonly applied to the sorts broken out of small fleeces, furnish a curious illustration of the increasing fineness of the pile, since the art of sorting was first made a distinct occupation, and likewise of the growing skill of the workman, who has almost constantly endeavoured, to discriminate the size of the hair with greater exactness. The name of the lowest sort, or

1. *Is Short-Coarse;* and very descriptive of its character.

2. *Livery.* } Old sorts into which the
3. *Abb.* } fleece was formerly divided.

4. *Second.* Probably a second or better abb, and the first alteration in the mode of sorting, which arose either from the improvement of fleeces, or in the art of breaking them. This and all the subsequent names, seem to have been in their regular succession, at the top of the list.

5. *Downrights.* Perhaps intended to convey the idea of superlative perfection.

6. *Head.* Or chief.

7. *Super-Head.* An advance upon the preceding sort.

8. *Picked-Lock.* First made perhaps in small quantities.

9. *Choice-Lock.* Still more excellent.

10. *Prime-Lock.* The last sort introduced into the list, and in one instance called *Pic-Nic;* alluding to the celebrated society of that name.

The names of the others are derived from these; and the sorts which they represent are introduced, into those parts of the scale, where the divisions of it were sufficiently wide to admit them. They are described as a Better Livery, Small Abb, Best Second, and by other epithets of the same kind This catalogue of sorts, rises according to the hair, or fineness of the pile, and is calculated to receive that portion of the fleece, which is adapted to cloths of the lighter colours; and in order to receive what is suitable only to the stronger tints, we run parallel to it a list of sorts, usually denominated Greys, of the first, second, and third order. The French manufacturers, who are sometimes very exact in their mode of sorting, particularly for the more delicate bran-

ches of the manufactures, have been recommended by M. Daubenton, to make use of a micrometer, in order to ascertain the size of the hair, with more perfect nicety.

The pile of my own sorts, when examined by means of a lens, applied to a graduated scale, generally arranges itself within the following dimensions. The Breech or Short coarse, receives all the short and very inferior locks, and the Livery, those of a finer kind; but with a considerable latitude of hair. The diameter of the pile in all the others, will be represented if we divide an inch, which we consider as unity, by the number annexed to each of the names.

Better-Livery, by six hundred.

Fine-Grey, by seven hundred and twenty.

Seconds, by eight hundred.

Downrights, by nine hundred and twenty.

Head, by one thousand.

Super, by eleven hundred and sixty.

Picked-Lock, by twelve hundred and eighty.

Choice, by, fourteen hundred.

A sample of moderately fine Spanish wool, reached sixteen hundred.

These numbers are the average of several repeated measurements, and are considered by me, as the standard of the sorts, to whose names they are affixed.

It is the object of the woolstapler, when he purchases fleeces, to obtain at a given price, as large a proportion as possible, of the superior sorts. With him the fineness of the pile is the first consideration, and the manufacturers, his customers, can always work up wool of the first quality, if they could obtain it at a price, which would allow them to meet the market. The thinness of the hair, can very seldom, if ever be considered as a detriment to the fleece, but coarseness very frequently unfits it for a variety of purposes. In his search for wool of a superior quality, the stapler is perpetually urged by the increasing demand, for goods of the most delicate texture; and it should induce the grower to collect from his flocks, fleeces distinguished by their superior excellency The consumption of Spanish wool amongst us, strongly evinces, that when a taste for fine cloths prevails, the materials will be obtained by the manufacturer, even though the use of them, tend to discourage our own woolgrowers, and to supersede the necessity of our native produce. Nor is there any danger to be apprehended, lest the cultivation of fine wool, should leave our coarser fabrics without the supply which they require, for the richer soils of the kingdom, will continue to be stocked with a race of sheep, whose pile will not for many ages, be adapted to delicate manufactures; and in proportion as farms improve in the low lands of Scotland, and almost through every district in Ireland, we may expect that the fleeces they yield will be better adapted to those purposes, for which the middle wools of England are at present employed. But should it be necessary to import the coarser article, it would be much more advantageous to purchase of foreigners, what is easy to be procured from many countries, than to depend upon one haughty nation, subjugated to the councils of our rivals.

In the present state of the woollen manufacture, the length of the staple, is an object of very considerable importance. It is that which destines the fleece to fabrics very different in their nature, and produced by instruments of dissimilar construction It will be difficult to convey to those who are not acquainted with the structure of the card, and the comb, an idea of the mode in which they are managed, and the purposes for which they are used, sufficiently accurate to enable them to conceive the object of the manufacturer, or the qualities of the wool suited to their respective operations. The card is a small oblong board, furnished with a great number of short crooked wires or hooked teeth, upon which the wool to be wrought, is hung by drawing it over them, in a direction contrary to that in which the hooks are bended.—When full, the instrument is placed upon the thigh of the workman, with the teeth upwards, and held there by the left hand, assisted by a handle attached to the card, while another card of similar construction, having the teeth downwards, and in a direction opposite to those of the first, is drawn over it with the right hand. The operation is continued until the workman thinks the wool completely torn between the teeth, broken and blended; when by a pecular mode of taking it from these instruments, he renders it fit for the spinning wheel. The object here is to break the wool completely, to blend it most intimately, and to form it into a thin roll, or "rovelling," of the slightest texture imaginable, held together only by the natural hookedness of the pile, or that disposition which it has to assume a zig zag, or waved form. Hence it is evident that the two chief qualities, which carding wool requires, is shortness of pile, and a disposition in the hair, to assume a crumpled or spring-like shape. If the first of these be ill adapted, labour becomes ne-

cessary to reduce the immoderate length of the staple; a greater expense is incurred, and more time is employed in working it; considerations which always have their weight among clothiers, and ought not to be disregarded by the grazier. It appears scarcely possible, that the staple of clothing wool, at least that part of it, employed in the manufacture of the finer fabrics, should be too short, if it possess only that degree of crumpledness, which will enable it to form a rovelling. One great advantage of the modern machinery arises from the more complete and uniform manner, in which the staple is broken; and the chief point of attention in the scribbler is to break it no farther, than the hookedness of the pile will admit of.

The peculiar shrivelling quality in wool, cannot prevail in too high a degree, if it be destined to make any kind of goods, which require a close, and smooth surface; for the greater number of the minute curves which it contains in a given length of the pile, so much the more it may be broken without injury, and every portion retain a sufficient degree of curvature to link itself with its neighbours, forming an inconceivably thin and transparent texture. The thinner this texture can be produced, and the greater degree of surface that can be given to it, so much the longer thread it will yield, and the cloth made from it, partake of a proportionable degree of delicacy. The necessity of this singular property of clothing wool, is obvious from the manner in which hair, a straight and smooth pile, is dissipated when wrought upon the same engines; the particles possessing no means of uniting themselves together, drop singly from the machine, produce no rovelling, and cannot be spun in the same manner as a woollen thread. When the pile is intended to form some of those fabrics, distinguished by a long and even knap, such as blankets and cloths, intended for large surtouts, too great a proportion of this shrivelling quality, might be detrimental, by rendering the knap less uniform and compact. But in the surfaces, which remain loose, and carefully disarranged, if I may be allowed the expression, as in the instances of cloths for light great coats, frizes and swan-downs, it is highly useful; and this variety among other circumstances, plainly suggests how desirable it is, that wool should be produced for a definite purpose, and not as it generally is, at random, and possessing properties, of which the grower is either entirely ignorant, or oberving them knows not their value, nor their use.

Yet the cultivator of wool, must not suppose that every kind of curvature, which he observes in the fleeces of his sheep, is a symptom of aptness in the broken pile to link together, and form a rovelling, the first rudiment of the thread; for there is a sort of crumplednes in the staple, which the clothier avoids, with almost as much care, as he employs in seeking for the other kind. It is distinguished by a singular adaptation of the curves, in the pile to each other, as though they had been formed by some external pressure upon the staple, and not by a cause effecting every individual hair, separately as it passed through the pores of the skin. The distribution of the hair in staples of this description, bears some resemblance to that of the grain, in a very crooked piece of timber, or perhaps it is more exactly like waved bars of metal, formed in such a manner, that the convex part of one, fits into the concavity of another. We can assign no reason, why this kind of wool should be disapproved, unless it arise from the superior length of the curves, by which means the staple cannot be broken, so much as it ought to be, and every portion still retain its power of uniting, with those which are near to it; this peculiarity however, is known to be detrimental, and ought to be avoided.

In some of the finer kinds of wool possessing this shrivelling property, in a high degree, the chord subtending the arc, is sometimes not longer than the hundredth part of an inch; but in those of inferior quality, where the curvature is not of the most valuable kind, the chord, or distance between one extreme point of the curve and the other, will measure the sixteenth, and sometimes even the eighth part of an inch. This great difference in the arcs, is easily discernable by every untaught eye, and more especially deserves the notice of the grower. He will find specimens of the inferior kind, most frequent in fleeces, which have been shorn from a sheep, the produce of very dissimilar progenitors.

No means have yet been discovered of communicating this peculiarly valuable, and nameless property to wool, in which it does not naturally exist. We depend therefore upon the breeder alone, to procure it, and are solicitous that in the various combinations of blood, which he is continually forming in his flock, that he should not lose sight of one of the distinguishing characteristics of wool, and that he should promote this as well as every other valuable quality with the utmost care. In a country where the carcase of

the sheep, is more valuable than its pile, and where the cultivation of wool is at most, only the secondary object of the farmer's care, it is desirable to render the blood as perfect as possible, in order that we may obtain from it without labour, even the minute excellencies of wool. But in Bucharia, where the shepherd is more solicitous about the fleece, than the health, or even the life of his sheep, artificial means are used, to produce something like this shrivelling property deemed so valuable in these western regions. There the lamb so soon as it is yeaned, is wrapped in linen bandages, is exposed to the sun, and has water poured upon it every day. As it increases in size, the fillets are gradually loosened, yet so as to preserve at all times, a considerable pressure upon the wool. By these means the pile is compressed to the skin, and assumes a waved or damasked appearance, which is esteemed its supreme excellency. If it could be supposed, that this compressure of the fleece, produces that kind of crumpledness, which is considered as an excellent quality in English wool, the process would be too expensive and troublesome to our shepherds, and the superior price for which such wool could be sold, not adequate to reimburse them. But it is more probable that we should find, if we had opportunities of examining the Bucharian fleece, that it was not at all more adapted to the woollen manufacture, than it would have been, had no such pains been taken with it.

Most of the wool produced at present in these kingdoms, is too long for the perfect operation of the card, and the first process through which it passes, after it has left the hands of the stapler, is calculated to shorten it. This is the precise object of the structure, and the use of the first engines, to which the pile is submitted. But the grower has a much more ready, and less expensive remedy in his power; for he can easily cultivate a race of sheep, whose coat shall be sufficiently short for the nicest purpose, or he can shear it more frequently than once a year, even before it has attained half its length. Yet he should be very careful, how he adopts a measure of this kind, for he will observe that the wool of the second clipping of one season, will not be exactly like that, which he procured at the other. Although somewhat inferior in quality, in the hand of an expert manufacturer, it may be applied to excellent purposes. If inclined to try the experiment, which is by no means a new one, the shepherd will naturally consider whether the state of his flock, the nature of the season, and the climature of his farm, will admit of it.

The wool intended for the manufacture of worsted goods of any description, is first reduced to a proper state for spinning, by means of the comb, an instrument very different from the card, both in its structure and operation. It consists chiefly of a piece of wood, shaped very much like the letter T. Through the head or traverse part of it, which is generally about 3 inches broad, a number of very long sharp teeth are thrust. They are finely tapered, made of well tempered steel, and generally arranged in three rows, about thirty in each, and placed nearly at right angles, to every part of the wood. The handle of the comb is represented, by the perpendicular part of the letter. In using this instrument, the wool is carefully hung upon the teeth, in such a manner as to project over the front of the head; when sufficiently filled and firmly fixed, another comb of the same kind is drawn through the wool, so as to unravel and lay each hair of it, smooth and even. If we consider the full comb, as the human head disgraced by a quantity of neglected, long and dishevelled hair, which we reduce to its natural and elegant order, we shall have a very just idea of the operation, and the use of this instrument, in the worsted manufacture. The very name shows its origin, application and use.

But the comb is used for another purpose, than merely to lay the pile straight and even; for the staple of long wool commonly contains a considerable number of hairs, shorter than the generality of those which compose the fleece, and also a number of long ones, which are tied in natural and indissoluble knots, highly prejudicial, when wrought into the worsted threads. These are collected by the process of combing, betwixt the teeth of the instrument, and by a very curious and dexterous mode adopted to strip the comb of its longer pile, the workman leaves them there until he has disposed of the long, clear and valuable wool, extracted by his fingers, and which from an old English word most aptly denoting the shape he has given to it, is denominated a sliver. When the instrument is cleared from the knots or noil, it is ready to repeat the operation. The comb therefore evidently requires, that the wool, to which it is applied, possess sufficient length to permit its arrangement upon the teeth, strength or toughness enough, to endure without being broken the muscular force, necessary to draw the instrument through it,

and such a degree of curvedness, as will enable it to form a close and compact sliver.

Even to this day, the comb is almost in its simple state,very few alterations have been made either in its structure,or dimensions, from the time when it was brought into Europe; and perhaps this is the principal reason, why we find so little difference in the hair of long fleeces, with respect to its fineness. By far the greater proportion of this kind of wool produced in England, when the pile is accurately measured, varies only about the two hundredth part of an inch. The diameter of the hair, is seldom larger than the space denoted by an unit, when the inch is divided by six hundred; it is commonly not finer than that measure divided by eight hundred; a very small quantity selected from fleeces of a shorter description, and submitted to the operation of the comb, will reach a thousand. To manufacture fine wool by means of this instrument, its structure must be less coarse, the teeth finer, shorter and placed more nearly together; the "load" applied to them considerably smaller, and should be wrought by a less nervous arm. But the manufacturers of worsted yarn, are the best qualified to decide upon conjectures of this nature, and I presume not to trespass upon their peculiar province, being satisfied with expressing an idea worthy of attention, and calculated I hope to excite it. In general if there be a demand for yarn of a finer quality, than is commonly produced, and for goods of a superior texture, manufacturers, unless chargeable with a culpable want of commercial spirit, are always ready to seek, and determined if possible to obtain the one, and to fabricate the other. When this laudable zeal is excited and encouraged, the raw materials necessary to the perfection of the articles in demand, are speedily either procured from abroad, or produced at home, and instruments adapted to the completion of the fabrics, are improved or invented.

Yet it seems to be peculiarly difficult, to apply the power of mechanism, to the manufacture of the finer sorts of worsted yarn, for although long since employed in the fabrication of almost every article of woollen goods, and even adopted with considerable success, in spinning the coarser numbers of worsteds, yet the comb, and the Catherine wheel, are the only instruments to this day employed, to furnish the more attenuated threads.—Perhaps the very nice adjustment of the comber's muscles, when he draws the sliver, and the adaptation of the spinner's motion to the length and the tenuity of the pile, when she extends her thread, require a dexterity, the result of habit rather than of judgment, which is not compatible with the unvaried action of an unintelligent machine.

It is necessary that the combing wools of our country possess some degree of curvature, or disposition to contract the length of the pile, for without it the workman could not form his sliver; but it is not desirable, that this property should greatly prevail. The reason why long wool should differ so essentially from the pile of shorter fleeces will be easily understood, if we attend the operation of the spinning wheel. In twisting a woollen thread, where the staple has been previously broken, and the fragments of it in the utmost disorder, are united only by their natural hookedness, the turning of the wheel rolls them together without arrangement, and when placed in every possible direction. But in spinning a worsted thread, where every hair has been previously disposed by the side of others, in the most regular order, the pile is drawn out in the direction of its length, every single hair being parallel to all those which lie near it, and is twisted in a spiral form, something like the threads of a compound screw. If those hairs contracted their length, in a considerable degree, they could not be correctly arranged nor drawn out in the regular order, which the work requires, but would be twisted into the thread, in an irregular and crumpled form; a circumstance injurious to the yarn, and to the goods which are made from it.

This general account of the different process through which wool passes, in the first stages of the manufacture, I trust, will be intelligible to every one, and sufficient to convince the grower, that the good qualities of the fleece are not of a capricious kind; that wool cannot be employed arbitrarily, to any purpose which the manufacturer may choose, but that nature points out its peculiar destination; that the workman is obliged to take the raw material with all its defects, and apply it to uses for which it is best adapted, although he observe in it qualities which injure his fabrics, and lament that it is not possible for his utmost skill and industry, to counteract their effects. Thus situated, he looks anxiously to the grower for assistance, as to the only person who can change the properties of the fleece, and produce a perfect staple, most resonably supposing that his wants should be attended to, and his wishes gratified.

Perhaps the independent spirit of the manufacturer might be mortified, if we hinted, that he is the workman of the shepherd, or we could ask the farmer, if he be not extremely solicitous to sow good seed, in order that he may furnish the miller and the meal-man, with a prime article, while he is reproachfully careless of the quality of that commodity, with which he supplies the comber, the spinner, and the weaver.

The length of pile suited to the comb, is upwards of four inches. The hose trade require a considerable share of that, which measures from four inches to eight, and the longer kind, is usually destined to the fabrication of worsted yarn; an article which admits of very great variety, in the mode of its manufacture. The shorter staple is applicable to woollen goods, of almost every description, which beside the whole quantity of this sort of fleeces produced at home, require very large importations from abroad; and no inconsiderable quantity of that pile, which has been grown to the length of combing wool, is submitted to the operation of the card. 'Tis chiefly that however, which possesses the contracting property in too great a degree; which is too weak for the comb, or is used to produce articles requiring a long and well raised knap.

Graziers are able to increase the length of staple, by various means. Most of them having been mentioned already, it will be sufficient here barely to repeat them. The management of the breed is not only the most natural and easy method, but that also which is most usually adopted. Its effects are more permanent than others, which are sometimes resorted to, but less pure from deleterious influence; for it is not unfrequently observed, that the ram communicating to his offspring, an increased length of staple, gives to it also a coarser pile. Feeding the sheep upon the richer grasses, upon turnips and oil cake, thus forcing both the carcase and the fleece, seems to be a method of increasing the length of wool, free from contaminating influence, but requires the animal to be constantly supported, even to the point of luxurious feeding; and the effects of the system, remain no longer than it is continued. Another method of increasing the length of the staple, pointed out by nature, but seldom, perhaps never adopted, with this particular design, is to keep the wool upon the back of the sheep, through two whole years; it requires only care, that the animal be not injured, by cold or by hunger, during the period that the fleece is growing.

The pliability of wool is another of those qualities in the staple, which deserve the closest attention of the shepherd, being esteemed by the manufacturer, an essential property. All inflexible and brittle substances, are evidently unfit for many of the operations, through which wool must pass, before it can be brought to that finished state of manufacture, which is intimately connected with the comfort and the elegance of life. It is impossible to produce from them a long extended thread, whose tenuity and compactness shall fit it for the action of the loom, the fulling-mill and the press. Indeed for many articles of the woollen manufacture, the pile cannot possess too much pliability, if it does not lose that tendency to contract its length, and assume a crumpled form, which we have already described, as one of the best qualities of the shorter staples. In the finer specimens of the Spanish wool, these two properties are admirably adjusted, the curvature of the pile is most delicate and true, its plastic quality is extolled, to almost proverbial triteness; but the staple of most British fleeces, is complained of as stubborn and elastic, counteracting the effects, which the spinning wheel should produce, and rendering the thread loose and bristly. Yet it must be recollected that woollen articles, require a great variety in the degrees of elasticity, possessed by the wool, from which they are made. Those designed to withstand the extreme rigours of the winter season, such as blankets and fearnoughts, as well as shags, and some sorts of carpeting, require a very large proportion of it, such as will enable the workman to form a long and swelling knap; but in the finer and thinner fabrics, whose surface is intended to be highly polished, a great degree of elasticity is very injurious. It always causes these substances to feel hard and prickly, because the ends of the hair starting from the body of the thread, and projecting from the surface of the cloth, affect the sense of feeling exactly like an immense number of short acute points fixed there. In finishing goods of almost every description, both of woollens and worsteds, excepting those already mentioned, the reduction of this extreme elasticity, is one object among others, of the workman's care. For this purpose he employs the shears, the singing stoves and the press, with its heated plates, and is able by these aids united with great industry, to form a surface smooth, soft and glossy; but the effect he produces upon stongly elastic wool is little more than temporary,

since moisture restores its former stubbornness, and deprives it of that gloss which had been impressed upon it. The effect of heat upon wool is very singular, for when applied in a moderately high degree, it seems to furnish the pile with the power of expanding itself, as though it excited a mutual repulsion betwixt the hairs of which the staple is composed, and is often made use of in the processes of the woollen and worsted manufactures, with great advantage; and when united with the pressure, it serves to fix the pile in the artificial direction which is given to it; an effect familiarly illustrated by the curling irons of the friseur. The adjustment of this neglected property may be recommended to the wool-grower's attention with great propriety, because if we may judge from some of the fleece produced by the most celebrated breeds, it is as much connected with the blood of the animal as any other quality, which can be communicated from the parents to the offspring, and is a very weighty consideration when we are estimating the perfection of the pile.

The short account given before of the manner in which wool is combed, and of the effect which the card is intended to produce upon it, will convey to those who have been familiar with these processes, some idea of the value of a proper degree of toughness in the pile. If the staple be weak and easily broken asunder, it will not be able to endure the force which is necessary to drag the comb through it. Breaking to pieces in the operation, the fragments collect in the instrument, and form only a noil, an article of no use in the fabrication of worsteds. The grazier may easily perceive when his combing wool is too weak, for if the staple break when strongly pulled with the fingers of both hands, he may always conclude that it is ill adapted to the manufacture of worsteds, and most commonly rendered totally unfit for it. If he attempt to promote the growth of a superior kind of long wool, it is of the utmost consequence that he notice the strength and soundness of the staple; for if the fleeces, which he has cultivated with care, and whose length of pile he has increased, be not sufficiently strong for the comb, he has not only failed to attain his object, but has greatly injured his wool. Peculiar care is necessary also, when the proprietor of a long-wooled flock attempts to render the pile finer by a selection of rams carrying a smaller fleece, for there are only few breeds in the kingdom, which yield fleeces at once fine, and sufficiently strong for the comb. A sensible wool-stapler, who has long observed the English fleece, and whose judgment and candour I have heard spoken of among spirited agriculturists, with the respect they deserve, writing upon this subject, complains that by the improvement of sheep in the counties of Huntingdon, Northampton, Leicester, and Lincoln, the qualities of the staple have been greatly injured, that the wool is rendered too weak for the old established manufactures, and adds, "this is an evil that must soon remedy itself, for deep strong wool will become the most valuable."

But on the contrary, the carding wools ought not to possess too great a degree of strength or toughness, because the process through which they pass, is designed to break the pile into small fragments, which is by no means accomplished when the strength of the hair is sufficient to endure the force applied to it with the card, and enables it by passing through the interstices of the teeth, to avoid their proper action. Nor should it be supposed that the shorter pile cannot be too tender, for it is sometimes found so decayed as to be broken, when passing through the engine, more minutely than the natural hookedness of the staple will admit of, it is then easily dissipated by the motion of the cylinders, and wasted; nor will the cloth, unless the wool of which it is made possess some considerable toughness, endure, without injury, the violent strokes of the fulling mill.

No technical name, I believe, has yet been given to the felting quality of the fleece, although it has been long applied to useful purposes, and is of essential importance in the fabrication of many kinds of woollen goods. It is the basis upon which the hat manufacture depends among ourselves, and has for many ages been applied abroad to the production of pieces of domestic furniture. In the fabrication of worsted goods it is not employed, nor is it necessary in the manufacture of stockings, blankets, baize, flannels, nor any other article not submitted to the action of the fulling mill. In some of them, when made of wool, in which it abounds, the housewife finds great inconvenience, and complains that her stockings and her flannels become too small for the wearer. From the different modes of manufacturing these articles, we may conclude, that in general the felting quality is a valuable one, in almost every description of fine and short stapled fleeces, and that it is not desirable in the greater part of the longer and coarser wools.—There are few circumstances, in which

the breeds of sheep, most commonly met with in these islands, differ more from each other, than in their power of yielding a fleece, which possesses fully, or is partially destitute of this valuable property. It may be described as a tendency in the pile, when submitted to moderate heat, combined with moisture, to cohere together and form a compact and pliable substance. But this property does not belong exclusively to the pile of the sheep, the hair of other animals, particularly the camel, the dromedary, the goat, and the beaver, are known to possess it in a high degree; perhaps few of the shorter furs are entirely destitute of it, although the longer hair, and that which has a polished and hard surface, with a degree of brittleness, exhibit only slight symptoms of its existence. I have never yet traced it in the hair of the human head, except in the disordered state of it, common in Poland, nor in that which is cut from the necks and tails of horses, nor in the bristles of the hog, although each of them have been observed minutely in the growing, the raw, and manufactured state.

Among the animals whose furs possess this valuable property, the sheep is most distinguished; and if we draw the conclusion from the quantity of felts used through all parts of the East, and the easy method in which some of them are formed, it seems that the wool of the western Asia is not destitute of it; that of France possesses it in a distinguished measure, and the envied produce of Spain, surpasses that of neighbouring countries in this, as in most other excellencies. From the fleeces of England, those have been selected as the best adapted to the fulling mill, which are obtained from the Norfolk, the Morf and the Cheviot breeds of sheep; while the South-Downs have been generally descried as producing a kind of wool, notwithstanding all that has been said in their favour, notoriously deficient at least of this good quality. Perhaps it may be owing in some measure to the chalkiness of the land upon which these sheep pasture, for we have observed that both these and the Wiltshire breed, when removed to different soils, produce a wool, which thickens in the fulling mill, although it proceeds more slowly in the operation than the pile of some other families. We must not conclude from this circumstance, that the difference observed in the felting quality of fleeces, is entirely owing to the land, because we find upon soils known not to be injurious to wool, different kinds of sheep, whose fleeces do not possess this quality in an equal degree. Graziers might easily ascertain to what cause the dissimilarity is owing; and surely when the South-Down breed is diffusing itself so widely over the country, it becomes the breeders of Sussex to wipe off every reproach from their stock.

The felting quality of wool is not evident to the eye; and though there be some very general appearances, which indicate the existence of the property, or its absence, yet they are so vague, that the best judges of wool consider this as a point to be ascertained only by trial. The application of moisture, warmth and pressure, is the most usual mode of bringing the quality into action. Without the aid of the first, it remains perfectly dormant; the two latter are employed to quicken the process. The tendency of thread, of almost every description, to contract its length, as it imbibes moisture, has not only been generally known, but some kinds are considered as acting so regularly, and so susceptible even of the slightest alteration, in the cause which affects them, as to authorize their application to the most accurate purposes of Natural Philosophy. But the woollen thread possesses the quality of retaining its contraction, after the cause which produced it has ceased to operate, while most others, such as lines of catgut, horse hair, linen, hemp, and cotton, assume their former length. We know too little at present to enable us to assign the cause of this permanent contraction; but conjecture that it is owing to the particles of the thread, which are brought into actual contact with each other, cohering exactly upon the same principle as the leaden balls do in the common experiment so often exhibited in lectures upon Natural Philosophy, to illustrate the attractive power of bodies. In this experiment, it is necessary to clear the lead from all foreign substances, at least in the points where the balls touch each other; but in the felting of wool, on the contrary, it is equally necessary to use some fluid, which intimately mingles itself with the pile, and promotes the attraction, as oil does when infused for the same purpose, between two plates of glass. Moderate warmth evidently assists the process; but why it does so, and how it acts, are in a great measure unknown. The degree of heat required to make the felting property act with its utmost force, is considerably below the boiling point of water; a higher temperature loosens the texture of the thread, and increases the elasticity of the hair, thus giving it a disposition to start from the substance of the cloth and spoil its surface. Pressure seems to be useful by bringing a greater number of points

into contact, and by divesting the thread of the air which is lodged in its interstices. But so little is known of the proceedings of nature in the operation of felting, that the manufacturer who would institute judicious experiments, superintend them with care, and publish the results, would perform a service useful to his country.

The mode of bringing this latent property into action, has not been always the same. In the ruder ages, it seems to have been excited by the pressure obtained from the weight of the human body; the cloth in its rough state being placed beneath the feet of the workmen, they continued to trample upon it until sufficiently thickened. Hence the person engaged in this employment was called a waulker, or walker of cloth; and the machine afterwards introduced to answer the same purpose, was denominated a waulking mill. Mrs. Guthrie, in her tour through the Taurida, informs us that the Tartars still use the patriarchal mode. Spreading two or three layers of "combed" wool moistened, "they tread it under foot for a few hours, and form their carpets without the aid of the loom, or the modern invention of cylinders." Yet this learned lady, who during her journey collected a great deal of information, is perhaps mistaken when she describes the wool as being "combed," because this process was first adopted long since the days of the patriarchs, and supposes a knowledge of the arts totally inconsistent with the spirit of her remarks. If the wool be prepared by any instrument; and not by the fingers alone, it is probably done by means of the wild teasel, at least we have reason to suppose so, if that plant is to be found there. The first improvement in the art of fulling cloth, I apprehend, consisted in substituting a sitting posture in the work people for an erect one; thereby enabling them to perform the work more rapidly and with greater ease. Mr. Pennant, the only one that I know of, who has given an account of the process in this stage, saw it performed in the isle of Sky, during his voyage to the Hebrides.

"On my return from Beinn-shuardal, he says, I am entertained with a rehearsal, I may call it, of the Luagh or walking of cloth; twelve or fourteen women divided into two equal numbers, sit down on each side of a long board, ribbed lengthways, placing the cloth on it. First, they begin to work it backwards and forwards with their hands, singing at the same time; when they have tired their hands, every female uses her feet for the same purpose, (still sitting) and six or seven pair of naked feet are in the most violent agitation, working one against the other; as by this time they grow very earnest in their labours, the fury of the song rises, at length it arrives to such a pitch, that without breach of charity, you would imagine a troop of female demoniacs to have been assembled. The subject of the song on this occasion is sometimes love, sometimes panegyric, and often a rehearsal of the deeds of the ancient heroes, but commonly all the tunes are slow and melancholy." This author gives an expressive plate of the Luaghad, but when he calls it "a substitute for the fulling mill," I apprehend his language is not quite correct.

The fulling mill was probably first brought into England by the Flemings, and does great credit to the age when it was introduced, both by the simplicity of its structure, and the perfection with which it performs the task assigned to it. While many boasted improvements, which have been introduced since that period, are again laid aside, this machine, like a venerable old man, stands amidst modern ones, the long tried faithful servant, the admiration of his juniors, and boasts, that he can perform the appointed task of every day with as much vigour as in his prime. This ancient engine deserves our regard, since it was the first combination of mechanical power, applied to the woollen manufacture, and more generally adapted through several centuries in every country of civilized Europe, than any other machine which can be mentioned. Something, though but little, has been done to metamorphose its appearance and action, but the alterations which have been made in it, when compared with those observable in other engines, are trifling, I had almost said contemptible.— Yet when a second Arkwright shall arise, and apply to it his wonderful genius, perhaps in some following age, the fulling mill will assume an appearance as different from that which it exhibits at present, and effect its purpose in a manner as varied, as the modern jenny does from the old spinning wheel, as the carding machine, with its revolving cylinders, and adjusted variation of motion, does from the petty instrument formerly wrought by the hand.

In the last age, the operation of the fulling mill was very laborious and tedious. A piece of cloth was then submitted to it for thirty successive hours, whereas now it is often rendered sufficiently thick in seven or eight; an instance of economy in the use of time and labour, which augurs well for the interest of the manufac-

turer. This remarkable alteration must be attributed partly to improvement, in the mode of spinning, to the superior skill of workmen, both in the loom and at the mill, to the selection of materials possessing the felting property in the strongest degree, to the general taste for thinner cloth, and perhaps to the improvement of the raw material. Yet it must be confessed that the wool-grower has contributed less to the public benefit arising from this source, than most other persons connected with the manufacture. If he be anxious to promote the growth of fleeces, in which the felting quality greatly prevails, I should recommend, from the little knowledge at present possessed, that he attend closely to the supply of natural, rich and nutritious yolk, which the pile receives while growing—that, where the soil, or the climate of his farm, will not admit the production of a sufficient quantity, he should seek for a substitute, adopting the best which presents itself; and to excite his attention, shall only repeat the expressive language of the clothier, who commonly asserts "that cloth is either made or marred at the mill."

When enumerating the essential qualities of fleeces, we must not forget the softness of the pile; for every person whose knowledge of the manufactured article is derived chiefly from the purchase of a coat or two, in the course of a year, attends more particularly to the colour of the cloth, and the effect produced upon the sense of feeling than to any other circumstances. Indeed the softness of the face, which a piece presents to him, is frequently considered as a test of goodness in the materials from which it is made. The manufacturer therefore, always attentive to the public taste, endeavors to produce by his loom a texture distinguishable for its silky smoothness; a quality which the skilful dresser attempts to heighten by every favourable circumstance he observes, either in the piece or the operations of nature. But the utmost skill can be only of little avail where the pile is naturally hard The pieces which are made from it, are invariably rejected, whether they be presented to the purchasers in the halls, the merchant's warehouse, or the retailer's shop; while those made from wool of a softer texture find a readier sale, and obtain a greater price. The difference of wool with respect to the quality under consideration, is really astonishing; some is so hard and hairy, that goods fabricated from it almost prick the hand; an effect always disgusting, and never completely counteracted, even in articles where the mode of manufacturing and of finishing them, most successfully conceals it. Most persons when speaking of this quality, and expressing it by the term already used, connect with it an idea of that effect, which silk produces upon the sense of feeling; but there are few who seem as though they intended to convey by the same term an idea of that sensation which is the effect of down or cotton upon the touch.—The first arises from the peculiar smoothness of the hair, the last from the little resistance which it makes to pressure.

This silky softness, like most other good qualities of the fleece, depends very much upon the breed of the sheep and the quantity of yolk which they constantly afford. Some districts yield a staple peculiarly smooth and delicate, in which, like the celebrated wool of Shetland and Vigo, softness forms the distinguishing characteristic. The Spaniard, than whom few can boast of a softer fleece, is so thoroughly aware of the value of this property, and the means likely to promote it, that he not only attends with peculiar care to the breed which travels to the mountains, but before shearing, encloses the sheep in sudatories, in order to saturate and soften the pile with yolk. And even among ourselves, the softest pile is collected, if the breed be similar, from flocks which have been kept in good condition, on loamy soils, and into whose fleeces the shepherd has been careful to admit no particles of absorbent earth. In the course of business, I once met with a small parcel of wool, collected from sheep of Westmoreland, which had been smeared, according to the custom of that country, with a mixture of tar and grease, in the autumn, driven into Huntingdonshire, and pastured during the winter and vernal months, upon the warmer soils of that southern district. In this part of the kingdom tarred wool was quite a novel article, and the impossibility of abstracting all the filth from the upper part of the staple, by the common mode of working it, alarmed the proprietor, who like an honest man, wound the fleece with the leech outwards, a practice neither common in that country, nor adopted by the same farmer in the other part of his parcel, in order that he might more effectually conceal the dirt. These rejected fleeces however, which passed from hand to hand because unfit to be mingled with the common pile of the neighbourhood, were finally sorted in my possession, and contained the softest wool of English growth that I ever examined. Its staple was perfectly free from kemps and wild hair, so common upon the backs of northern sheep,

and it was much finer than the wool usually found either in Westmoreland or Huntingdonshire: but too long for the card, and too tender for the comb; in other respects it possessed almost every valuable quality. No means presented themselves of ascertaining the precise effect produced by the change of climate, food and treatment, which these sheep had most probably experienced; but the facts just stated, lead us to conjecture that it was very considerable, and extremely beneficial They induce us to wish that the experiment were repeated with more accurate attention to the flock, especially as the increase of softness in the southern wools, is most sincerely to be wished.

Enough has been said already upon the colour of wool to illustrate the advantage of perfect whiteness; but it seems desirable that the appearances in British fleeces inconsistent with this excellency, should be more minutely pointed out, in order that the grower may observe and correct them. The yolk often leaves in the pile a deep tint of yellowness, which ought to be avoided, if it be possible to prevent it, without injury to the staple. A sensible French chemist made some experiments, connected with the art of bleaching wool, but did not extend them far enough to attain any very important information, and contented himself with referring to the well-known mode of stoving cloth by the fumes of sulphur; nor has any other person discovered a process applicable to the unwrought staple, by which it may be rendered perfectly colourless. We turn therefore to the only one who can dispose the qualities of wool as he pleases, and solicit attention. In some sorts of wool, which possess valuable qualities in the highest degree, and whose yolk has evidently been copious and rich, we see no unfavorable tints, and are induced to suppose that perfection of colour may be attained without sacrificing any good quality of the staple. Even in wool reputed white, we observe some smaller deviations from that clearness which is desirable in all fleeces, and besides the yellowness just mentioned, as the effect of the yolk, fleeces very frequently possess from the constitution of the sheep, or the nature of the soil whereon it feeds, a blue, a brown, or a redish tinge. Very commonly grey hairs are mingled with the white ones, so intimately as to escape the notice of the most penetrating eye until the pile be scoured; an operation not always performed before it is made into cloth, when the manufacturer sometimes finds that it is not fit to be imbued with the more delicate tints, and on that account not adapted to the purposes for which he designed it. Perhaps more than half the quantity of short wool produced in England is not free from this defect, a circumstance which should lead the grower to attend to it more minutely than he has done. All artificial tinges which he gives to the fleece, by means of ruddle or ochre, or any substance of that description, in order to increase the beauty of the flock, injures the pile as much as the rouge used by our ladies of fashion, to heighten their native charms, does the skin to which it is applied. When this painted wool is submitted to the dyer's hands, unless washed at some little expense of time and labour, the foreign substances mingle with the colouring ingredients and spoil their effect But indeed what can we expect but dull and heavy tints, faint, muddy and uncertain colours, where wool is dyed, as is too much the custom in Yorkshire, without being scoured, in pans unwashed, and with materials mixed together upon a floor unswept, where a little before, perhaps, have been mingled ingredients calculated to produce a totally different tint. Such slovenly practices deserve reprehension. The French are said to be much cleaner in their manner of dyeing than we are, and their colours superior to our own.

Another object to which the wool-grower should attend more closely than he has yet done, is the Specific Gravity, or relative weight of the pile. If desirous to ascertain the comparative weight of different samples, he must carefully bring each of them to the same state of purity; must drive off the moisture which wool obstinately retains, and extract from it all the air lodged in the interstices of the staple If this be not exactly performed, the experiments he may institute will be trifling and delusive. When first attending to this subject, in order to render my judgment of its value more correct, I conceived that the gravity of all wool, like that of pure gold, was exactly alike, and supposed that a correct knowledge of the real weight of pure wool would enable me to ascertain, with the utmost precision, the quantity of other substances mingled with it. But it soon appeared that wool in the purest state to which I could attain, did not possess exactly the same relative weight; that when compared with water, it varied from seventy-five to a hundred, i. e. some samples were really lighter than others in the proportion of five to three. The experiments were deemed correct enough for the common purposes of trade, but are not considered sufficiently accurate for the nicer

calculations of the philosopher. Nor was I able to ascertain, whether the difference observed was merely accidental in the particular wools under inspection, or followed some general law connected with the breed, or the cirumstances in which the pile was produced The mere coarseness or fineness of the staple does not effect the specific gravity of it, nor does the fine, close, and well-grown wool of the shoulder differ very materially in this respect, from the thin and hairy breech. The clothier commonly examines this property of wool, without being conscious of the principles upon which he depends; he is well aware that a given weight of some kinds of wool will produce more cloth than the same quantity of a sort equally fine, shorn from a different pasture; but he usually attributes the differences of the bulk, which he perceives in sheets of wool, to the purity of one sample, and to the extraordinary quantity of dirt mingled with the other. Such a decision is generally very correct; but when he measures the size of a sheet with his eye, and tries the tenseness of it with his fingers, he should recollect that there is a difference in the elasticity of wool, in the manner in which the pile is disposed, in the mode of packing it, and in the specific gravity which may cause as great a variation in the appearance of a package, as that arising from the purity or dirtiness of the staple. The importance of rendering wool as light as possible, is clear to every one who considers that the quantity of cloth, which a given weight will produce, is the true test of its value. Yet the grower, as though totally negligent of so plain a principle, has often been solicitous to increase the weight of his fleece, without considering whether he augmented the quantity or the density of the pile; a distinction with which every other clothier must be acquainted, although he may express his ideas in different language, for he buys the material by weight, and sells it when manufactured by measure. In this case there can be no doubt respecting the person from whom we must expect improvement The manufacturer cannot change the nature of the materials; he must work such as he finds, and from among imperfect ones, selects the best.—But since the art of combining the properties of the parent sheep, in their offspring, is generally known, the grower of wool has it in his power to produce surprising alterations. Nature has appointed agriculturists the chief dispensers of her favours, and society justly expects much from their attention.

The smell of wool, though very often applied to, as a test of its condition, is one of the least important circumstances connected with it. Provided it produce no disagreeable sensation upon the olfactory nerves, and betray none of the effects of moisture, there is no one particlar scent which we deem preferable to another.—Pure and perfect wool, I suspect has no smell; yet it is a very singular fact, that fleeces produced in different countries, and even in the various provinces of the same kingdom, convey by their peculiar odour a strong attestation of the district were they grew. The fact depends chiefly, I suppose, upon the construction of the animals; because the fleece of a ram is distinguished from that of any other sheep, and quadrupeds of different tribes are well known to produce very dissimilar sensations on the sense of smelling. It would be curious, perhaps more than curious, to ascertain the cause of this fact more accurately, especially as our researches into nature are generally repaid by the acquisition of useful knowledge.

But a far more valuable quality remains to be noticed, one which the wool-grower should observe with the closest attention. In technical language, it is called the trueness of the hair; and I know of no other phrase, which so completely conveys the idea. When speaking upon the quality of fleeces as they exist in a neglected state, it was observed that they are composed of coarse shaggy hair, and a more soft and downy pile. The natural effect of culture, is the banishment of the coarse and brittle filaments from the staple, and the increase of that substance, which is more soft and pliable. But without minute attention, it requires a long coarse of years to render the pile perfect; and the cultivators of the fleece relax their attention most commonly before they have rendered the pile uniform.—Most of the fleeces of Scotland are still defective; many of the finer sorts produced upon the English plains, and even those of Italy and Spain, notwithstanding their boasted superiority, cannot claim an absolute freedom from a hair, which debases the staple. Sometimes these inferior filaments are thinly scattered through the pile, and rising above its general surface, give it a loose appearance, which authorizes the common representation of it as a bearded fleece.

Under the general description of wool not true-haired, we also include that in which the points of the staple are coarser than the part of it, which rose from a less distance from the pelt; and also that where any portion of the filament is perceptibly thinner than another, to the unassisted eye. When examined with a

microscope, we seldom find wool equally fine, through the whole length of the pile Frequently it becomes suddenly thinner, as though the pore through which a filament passed, had been contracted and gradually expanded itself, again to its natural dimensions, permitting the hair to become in the same proportion, more thick and even. Sometimes a hair when seen in profile, has one of its outlines straight and even, while the other is very irregularly indented, as though its pore had suffered a contraction only on one side. Each of these minute variations, confirms the opinion of Dr. Anderson, who supposes that the pores of the skin, expand and contract, as the temperature, to which the sheep is exposed, rises to a higher degree of warmth, or becomes more cool. Yet as these irregularities do not materally affect the value of manufactured articles, unless easily distinguished, it seemed right to bound the description of a bad quality, by a restrictive phrase. When these sudden contractions in the size of the pile, occur in long wool, the effects are more pernicious than in the shorter piles, for they often render the staple too weak to endure the violence of the comb; and totally unfit it, for its natural and appropriate manufacture. This thinner part of the filament, which the manufacturers denominate a joint, is more frequently observed in hog fleeces, than any other; and is commonly found near the bottom of the staple, evidently the effect of a cause, which operated while that part of the pile was passing through the pelt, and which continued to affect it only for a short period; for the parts of the staple immediately above and below the joint, appear in their natural state — The precise period when the effect was produced, may be ascertained by observing the length of wool, which has grown since: and perhaps this circumstance may lead to the true cause of it, which I believe will generally be found, to be either cold, hunger or ill-health.— This joint is more observable in long wool than short, doubtless because the former grows much more rapidly than the latter, for a sheep of the heavier breeds, produces a staple of fifteen inches long, in the same time, that one of a different kind perhaps, will not extend to more than three; and the animal yielding long wool is commonly more tender than the other, less able to endure the bitterness of the blast, and the gnawing pains of hunger. Perhaps the difference between one part of a filament and another, may be more considerable than wool-growers are aware of. I have met with some hairs, selected from the worst part of a fleece, where the difference between the diameter of the point, and that of the other end was at least as five to one; so that a given length of pile, when selected from one part of the staple, weighs twenty five times as much, as the same length separated from the other part. This extreme case is mentioned in order to convince the grower, that the trueness of the hair, is a quality of no trifling consideration, and if possible to excite his attention to it, for there are very few British fleeces, in which the points of the staple, are not visibly coarser wool than their bases.— 'Tis with pleasure we acknowledge, that much has been done to remedy this defect, although constrained to add, much remains to be effected

The short account already given of the operations of carding, combing and spinning, is sufficient to show how very important it is, that the manufacturer should be able to select wool of a perfect pile, more especially that it should possess no inequalities of the filaments; that they should be equally elastic, and strong through their whole length; for wool destitute of uniformity in any of these particulars, will place its coarser portion upon the surface of the cloth. This fact is repeated, as one which ought to be imprinted upon the memory, both of the stapler and the shepherd.

Another kind of hair is sometimes found in the staple, which is more pernicious to cloth, and most other articles, than the filaments already described. It is generally short, pointed, brittle and opaque, exactly like that produced upon the faces and shanks, of most English sheep. Its colour is commonly white, sometimes gray or brown; and among British manufacturers, it is called a kemp or stichel hair, and not unfrequently from its resemblance, to that of the feline species, cat's hair. Kemps are commonly much coarser than the wool, in which they are found, and often so intermingled with it, as not to be separated, even by the motion of the scribbling machine. They will receive no artificial tints, but from the most corrosive ingredients; and by their hardness, the sharpness of their points and their coarseness, spoil the article in which they are mingled. The fleeces most commonly infested with them, are those produced by neglected breeds of sheep, or animals grown old, and are common both to British and foreign families. In long fleeces they are not very frequently observed, but when met with, are collected in the noil, and render it much less valuable.

These are the most general qualities of the fleece, to which the manufacturer attends, and we hope, that they are described in such a manner, as will enable the wool-grower, to form some distinct notions upon points, which he should keep constantly in view. He has often complained, that the stapler appeared to him, capriciously to prefer one fleece to another, and has been confounded to observe, that improvements suggested and warmly recommended by one buyer, have been totally disregarded or condemned, as pernicious to another But had the farmer recollected, that wool is used for very various purposes, which require a corresponding difference in the materials; that the manufacturer of one article, seldom understands the mode of producing another; and that most staplers content themselves with purchasing only one kind of wool; he would rather have expected a difference of opinion, than have been surprized when he found one. It is singular that a trade so very simple, as that appears to be, which consists in purchasing a quantity of fleeces, breaking them into a number of arbitrary divisions, and selling the sorts in their raw state, should be so much divided: one of the best proofs that the art, simple as it appears, has attained a high degree of perfection Persons who purchase their wool in the South of England, for instance, seldom either buy, or understand the value of fleeces, produced in the north. Some lay out their capital chiefly in the East, others almost entirely in the West, and some take only a middle course. Numbers do business in long wool, a great many confine themselves entirely to the shorter pile, while a few understand only the lower sorts; or trade in the finer, or in foreign wools alone. We speak not here of persons confined by local situation, to only one kind of fleeces but of those who reside in the very market where every kind is consumed, and before whom the kingdom and the world is open; of persons through whose hands, by far the greater part of fleeces produced in the island must pass, and who perhaps are the most favourably situated, for attaining correct information, respecting the qualities of the fleece, and state of the manufacture They expect much from the growers of the pile, but are disposed to exercise candour towards them, recollecting that there are circumstances in every farm, to which the grazier must attend, whose nature he cannot change, and whose effect notwithstanding all he can do, will still be visible. It is desirable to ascertain, how far their pernicious influence is unavoidable, and what are the means of counteracting it. The wool-grower's own interest, the main spring of almost every commercial and agricultural transaction, prompts to the investigation and to the use of remedies. See Animals Domestic. See also Manufacture of Cloth, &c.

WORM WOOD, *Salt of.* See Carbonate of Potash.

WORM TUBE. See Distillation.

WORT. See Brewing.

WOUNDS *in Farriery.* See Farriery.

WRITING INK. See Ink.

X

XANTHORHIZA, *tinctoria*, Shrub Yellow Root. Is a native plant of N. Carolina.

Dr. Woodhouse in the 5th vol. of the Medical Repository of New-York, observes, that the *Xanthorhiza tinctoria*, contains a gum and resin, both of which are intensely bitter; the resin is more abundant than the gum.

It imparts a drab colour to cloth, and a handsome yellow to silk, but the dye will not take, on cotton or linen. The different mordants which were used, altered the shade of the yellow colour considerably, but did not appear to render it more permanent While every shade of this elegant colour can be obtained, from that truly valuable dyeing drug, the quercitron bark, (black oak,) Dr. Woodhouse thinks it will always supersede the *xanthorhiza*, and every other native dye, among which that of the *hydrastis Canadensis*, may justly be reckoned the most superb.

Dr. Mease, remarks, that the watery extract of the grated roots, mixed with alum, and added to Prussian blue, was first used by Mr. James Bartram, for colouring plants, and the plumage of birds of a green colour. The green is far more lively and elegant, than that made of gamboge and Prussian blue, which is generally used for painting in water colours, and stands well in the shade, but soon contracts a dull colour, when exposed to a bright light, and to a high temperature. Various subjects coloured by this green, and inclosed in a book, were as lively after one year, as when first painted.

Y

YARN. The conversion of flax, hemp, cotton, wool, &c. into filaments or threads, is denominated yarn.

Originally the distaff was the means employed to perform the operation, without any other means, but at present the operation of spinning is performed in the large way, by the help of machinery. See SPINNING and MANUFACTURE OF COTTON; in which the machinery is described. In addition, however, it may be proper to notice in this place, the machine invented by Messrs. Kendrow and Porthouse, though it has been superseded by more modern inventions. For a more minute description than what is here given, we refer the reader to the 16th vol. of the Repertory of Arts.

The machine consists of a frame, which supports a cylinder, three feet in diameter, and ten inches in breadth; made of dry wood or metal; and its circumference being covered with smooth leather. On this, are placed six rollers, also covered with leather, and upheld in their situations, by slits made in a piece of wood, in which the iron axis of the rollers move, at the same time suffering them to press on the principal wheel: such rollers are of different weights; the highest on the cylinder weighing two stone, while the others gradually decrease, so that the lowest is only two pounds in weight. A cloth is placed beneath the cylinder, that revolves upon two rollers, inserted in the frame; and by its side there is a table of an equal length and breadth, furnished with two similar cloths.

The workman lays on this table a greater or smaller quantity of the material intended to be spun, according to the degree of fineness required; spreading it uniformly on the cloths, whence he removes and applies it to the revolving cloth. The rollers and cylinders are then put in motion by wheel-work, moved by a horse, water, or any other impulsive power; the flax, &c. is drawn forward, and extended, during its passage, into a thread or sliver; which, on being submitted to the action of a similar machine, but of different dimensions, is spun into thread of various degrees of fineness: after the yarn has thus passed beneath the rollers, it falls into canisters below, for its reception.

YARN, *Dyeing of*. See DYEING.

YARN, *Bleaching of*. See BLEACHING.

YARN, *Weaving of*. See WEAVING.

YEAST, or Barm, is the froth which rises on beer, during its fermentation.

The uses of yeast are numerous, and the source from which it is generally obtained, is not sufficient to supply the demand. Unless properly preserved, when kept in large quantities it is apt to spoil. We propose therefore to shew how it may be made from several materials, and how to preserve it, when made, be the modes of obtaining it what they may. For this purpose, we have availed ourselves, as heretofore, of the observations of different gentlemen.

In the 2d vol. of the "Memoirs of the Philosophical and Literary Society of Manchester," Mr Henry has published a method of preparing artificial yeast, by which good bread may be made, without the aid of any other ferment. He directs flour and water to be boiled to the consistence of treacle; and when the mixture is cold, to saturate it with fixed air. Next, it must be poured into large bottles with narrow mouths, which should be loosely covered with paper; and, over this, with a slate and a weight, to keep them steady. The bottles ought now to be placed in a room, the temperature of which is from 70 to 80° Fahr. and the mixture be stirred two or three times in the course of 24 hours. At the end of about two days, according to Mr. Henry, such a degree of fermentation will have ensued, that the mixture acquires the consistence of yeast. In this state, the flour, intended to be made into bread, must be incorporated with such artificial barm, in the proportion of six pounds of the former to one quart of the latter, and a due quantity of warm water. The whole is now to be kneaded together in a proper vessel, covered with cloth, and suffered to stand for 12 hours, or till it be sufficiently fermented; when it should be formed into loaves, and baked. Mr Henry adds, that this yeast would be more perfect, if a decoction of malt were substituted for water.

A simple decoction of malt, however, is now fully proved to be convertible into yeast, fit for brewing: this discovery was made by Mr. Joseph Senyor, on whom the Society for the Encouragement of Arts, in the year 1790, conferred a bounty of 20*l*. He directs three wooden or earthen vessels to be procured, one being capable of holding two quarts, the other

three or four, and the third five or six quarts. A quarter of a peck of malt is then to be boiled for eight or ten minutes, in three pints of water; when one quart must be poured off the grains, into the first vessel: as soon as the liquor becomes cool, such vessel ought to be removed towards the fire, or to a temperature of about 70 or 80° of Fahrenheit's thermometer. In the course of 30 hours, the fermentation will commence; when two quarts of a similar cool decoction (made, we suppose, from the same malt,) must be mixed with this yeast in the second or larger vessel; and be repeatedly stirred in the manner practised in common vats. As the fermentation increases, a greater portion of the like decoction must be added, and be worked in the largest vessel: thus, at length, a sufficient quantity of yeast will be produced, for brewing 40 gallons of beer.

This useful contrivance of Mr. Senyor, is farther confirmed by the recent experiments of a correspondent, whose plain and interesting account we are induced to quote in his own words: "I caused (says he) a gallon of rather weak wort to be made; with part of which, when cool, I filled the middle part of Nooth's machine: as soon as it was thoroughly saturated with fixed air, I mixed the whole, and placed it in a wooden vessel near the fire, the weather being rather cool. In about 24 hours, there were some faint signs of fermentation; yet, at the expiration of the fourth day, I obtained no more than two table-spoonfuls of very indifferent yeast; and the wort had become extremely offensive. As the yeast was not only very poor, but in too small a quantity for any domestic purpose, I made an infusion of malt, and a decoction of hops, in the manner used among the inhabitants of the island of Jersey, when they find it necessary to increase a small quantity of brewer's yeast. To this preparation, I added my two spoonfuls of yeast; let the mixture stand 24 hours, then poured off the watery part; mixed the sediment with an increased proportion of the malt and hops; which fermented, and produced yeast enough to work a gallon of strong beer, that yielded a pint of very fine yeast, of which excellent bread was made. Having some reason to suspect, that the fixed air, was of little or no use in this experiment, and that a wort might be made, which would ferment of itself, before the liquor was spoiled by too long keeping, I caused to be made four gallons of good wort, rather above porter strength, well hopped, and with a considerable quantity of colour, and treacle, to preserve it from putrefaction. It was equally divided, one-half impregnated with fixed air, as in the first experiment; each was put in a wooden vessel, and both were placed in an equally warm situation. At the expiration of 24 hours, there being no signs of fermentation, I stirred in a tea-spoonful of salt, and shook a little flour on the surface of each. In 12 hours more, the unimpregnated wort, shewed some appearance of fermentation, which went off, and was renewed by placing the liquor near the fire; and at the 74th hour, it had a tolerably good head of yeast; but the impregnated wort, was only beginning to ferment. In 24 hours after, we took a pint of yeast from the wort, which was not impregnated with fixed air, and about a tea-cupful from the other, which was as inferior in quality, as in quantity. The worts were then mixed, put into other vessels, and bid fair to become excellent beer. I cannot say that this is a very expeditious mode of making yeast; but I believe it is a sure one, and within the power of every person, who can procure the necessary ingredients for making good beer." Our correspondent, therefore, conceives to have proved by his experiment, "that fixed air is, at least, not requisite to produce a fermentation in beer."

Dr. Lettsom ("Hints for promoting Beneficence," &c. 1797,) recommends the following preparation as a substitue for yeast: Boil four ounces of flour in two quarts of water, for half an hour; and sweeten it with three ounces of Muscovado sugar. When the mixture is nearly cold, pour it on four spoonfuls of yeast, into an earthen or stone jar, sufficiently deep to admit the new barm to rise: it must now be well shaken, placed near the fire for one day, and then the thin liquor poured off the surface. The remainder is next to be agitated, strained, closed up for use, and kept in a cool place. Some of the yeast thus prepared, ought always to be preserved, for renewing or making the next quantity that may be wanted.

The following method of preparing excellent yeast, we state from the "Transactions of the Economical Society of Petersburgh," on the authority of Baron Von Mestmacher: when the wort is made, and it becomes necessary to provide yeast for its fermentation, he directs 40 gallons to be drawn off, into a vessel provided with a lid, and capable of holding one-third more than that quantity. Next, seven pounds of leaven are to be dissolved in a little wort, and mixed with the forty gallons: 17 pounds of rye-meal, and an

equal quantity of ground malt, must now be added, by agitation for some minutes, and suffered to stand for half an hour. At the end of that time, a spoonful of the best yeast ought to be incorporated with this compound; the lid is to be placed upon the vessel, and the whole to remain undisturbed for 48 hours; when the mixture will be found converted into 60 gallons of remarkably good barm.

In the 1st vol of "Annals of Agriculture," Mr. Kirby suggests mealy potatoes to be boiled, till they become perfectly soft, in which state, they must be mashed with hot water, so as to acquire the consistence of yeast. Two ounces of coarse sugar, or molasses, are then to be added to every pound of potatoes; and, when the mixture is lukewarm, two spoonfuls of barm must be stirred into it, according to the proportion above stated. This composition should not be removed towards the fire, or to a warm place, till the fermentation cease; when a certain portion may be kneaded with flour, which ought to stand eight hours before it is baked. Mr. Kirby observes, that every pound of potatoes, thus managed, produces nearly a quart of yeast, which will remain good for three months. The roots, however, ought, in the opinion of Mr. Borderly, to be perfectly ripe and well-sprouted; as in the contrary case, no fermentation will ensue.

Similar to this preparation, is the substitute for yeast, contrived by Mr. Richard Tillyer Blunt; in consequence of which he obtained a patent, in October, 1787.— He directs eight pounds of potatoes to be boiled in water, in the same manner as for the table: after which, they must be mashed; and, while they are warm, two ounces of honey, or other saccharine matter, and one quart of common yeast should be added. Three pints of this compound are sufficient, with the aid of warm water, for making the sponge; and, when this begins to sink, the dough ought to be formed into loaves, and baked.

The mode of separating beer from yeast and preserving the yeast for a great length of time, and in any climate, is thus given by Mr. Matthew, who obtained a patent for the above mentioned object, which may be found in the Repertory of of Arts, vol. v. p. 73. Mr. M. uses a press, with a lever, the bottom made of stout deal, oak, or any other timber fit for the purpose, raised with strong feet a convenient height from the ground, so as to admit the beer to run off into whatever is prepared to receive it. Into the back of it, is let a strong piece of timber, or any other fit material to secure one end of the lever, the top of which is secured by being well wedged up to a girder, or the joists at the top of the building. In this piece of timber is mortised one end of the lever, which is fastened into the mortise with an iron pin, or otherwise properly secured; the whole well secured with iron work The yeast is then put into bags made of sail cloth, or any other strong cloth or material, and carefully tied or secured, then placed flat on the press; a board is then laid on it, and the lever let down on it, and weights are hung at the other end of the lever by hooks or otherwise, and weights are added as the beer runs from the bag, care being taken not to burst the bag, nor force the beer out too thick; to prevent which, the bag is placed in a trough of a proper size, with a false bottom, bored full of holes, (the sides and ends being likewise bored full of holes) and blocks put above for the lever to act upon. When a sufficient weight has been added so as completely to force the beer out, which may be done by a screw press, if necessary, the yeast, which remains in the bag, will crumble to pieces like flour. It must then be thinly spread upon frames made with thin canvas, hair cloth, or any other thing, which will permit the heat to pass freely through it, in a room, kiln or stove, or other place, where a regular heat can be kept up to the temperature of from about eighty to ninety degrees; observing to break it fine as it dries, by passing a board, or other fit thing lightly over it. When completely dry, put it in tight casks, or bottles, so as to exclude the air, or any damp from it, and it will then keep a great length of time, and in any climate When wanted for use, it may be dissolved in a small quantity of wort, or sugar and water, of the temperature of from about eighty to ninety degrees, when it possesses the same quality as fresh liquid yeast.

Dr. Mease has given the following interesting observations on this subject, which contain a fund of useful matter:

The following mode is most commonly adopted out of the great towns in the United States: Four table-spoonsful of bran or shorts, and one of hops, are boiled in a quart of water, and set by the fire to ferment. A small quantity of salt to the water, wherewith the flour is kneaded, is an improvement. With this, however, the practice is to use leaven saved from a former baking.

Where bread is made from leaven alone, some sugar should be added to correct the sour taste, and probably a small quantity of pearl-ash, would add to

the rising of the bread, as well as correct the acid of the leaven.

An useful substitute for yeast, may be obtained by nearly filling a bason, or tea-cup, with bruised, or split pease, and pouring on them boiling water. The whole is now to be set on the hearth, or other warm place, for 24 or 48 hours, according to the temperature of the season. At the end of that time, a froth, possessing all the properties of yeast, will appear on the surface of the fluid. This method, we understand, is commonly practised in the eastern countries; and the barm, thus procured, is said to render the bread light and palatable.

To the different modes of procuring yeast, alseady specified, we shall add an easy and expeditious process, which appears to be very plausible; and has lately been communicated to the editor, by an anonymous correspondent, he cannot therefore vouch for its success. Take six quarts of water, and two handfuls of wheaten, or barley meal, stir the latter in, before the mixture is placed over the fire, where it must very gradually simmer, and at length boil, till two-thirds of the fluid be evaporated, so that it may consist of two quarts. When this decoction becomes cool, incorporate with it (by means of a whisk) a powder, consisting of two drams of salt of tartar, and one dram of cream of tartar, previously mixed. The whole should now be kept in a warm place. Thus a very strong yeast for brewing, distilling, and baking, is said to be obtained. For the last mentioned purpose, however, such barm ought to be first diluted with pure water, and passed through a sieve, before it be kneaded with the dough; in order to deprive it of the alkaline taste.

The preservation of yeast for a considerable time, is an object of equal importance to that of producing it artificially — Hence, it has been recommended to put a quantity of that commodity into a canvas bag, and to submit the whole to the action of the screw press, so as to deprive it of all moisture; in consequence of which, the barm will remain in the bag, as firm and tough as clay. In this state, it must be packed in casks, well secured from the access of air, and may ke kept in a sound state for any period of time. We believe, however, it would be more safe and advisable to form the pasty yeast into circular, flat vessels, resembling tea-saucers, and in that sate to dry the whole mass, either in the open air under shade, or in the moderate warmth of a baker's oven.

Another mode of preserving yeast, consists in throwing a *withy*, or the young shoots of willows, twisted together, into the vessel where the yeast is working; and suspending them in a warm room, till the next opportunity of brewing arrives. We conceive, however, the following expedient to be preferable, both in point of cleanliness and economy; it being successfully practised by some careful housewives. Take a clean wooden bowl, of such size as may be most convenient; spread a regular coating of yeast around its inner surface; and, as often as this dries, repeat the process, till a thick cake be formed. The vessel must be kept in a dry place. When any barm is wanted, a small piece may be cut out; and, after dissolving it in warm water, the solution will answer all the purposes of fresh yeast, whether designed for baking, or for brewing

The following process being advantageously employed in Germany, for preserving barm, so as to be fit for all domestic uses, after a considerable time, we have inserted it for the benefit of our country readers: When the yeast is taken from new beer, it must be put into a clean linen bag, and be laid in a vessel half full of dry, sifted wood ashes; the whole is then to be covered to the thickness of three or four inches, with similar ashes, and be pressed together. In this situation, the barm should remain for a day, or longer, if it be necessary; when the ashes will absorb all the moisture, and the yeast acquire the consistence of a thick paste. It must now be formed into small lumps, or balls; dried in a moderate heat; and kept in bags, in an airy, dry place. When any barm is wanted, a few of such balls may be dissolved in warm water; or, which is preferable, in beer; and they will answer every purpose of fermentation.

In relation to this subject, may be added the following method of fermenting a large body of flour, with a small quantity of yeast, given by Mr. James Stone, of Amport, Hampshire. Repertory of Arts.

Suppose, says he, you want to bake a bushel of bread, and have not more than one tea-spoon full of yeast; put the flour into a kneading trough, and take about three quarters of a pint of warm water, and the tea spoonful of yeast, which if thick and steady the better; put it into the water, and stir it until it is thoroughly mixed; then make a hole in the middle of the flour large enough to contain two gallons of water; pour in your small quantity of yeast, mixed with water as above; then take a stick, about two feet long, and stir in some of the flour, until

it is as thick as you would make batter for a pudding; strew some of the dry flour over it, and let it rest for about an hour, for in that time you will find this small quantity raised so that it will break through the dry flour which you shook over it; then pour in about a quart more of warm water, and stir it with your stick as before, and leave it for two hours more; you will find it rise, or break through the dry flour again; then add three quarts, or a gallon more of warm water, and stir in the flour again; and in about three or four hours mix up the dough, and cover it warm. In four or five hours more you may put it into the oven, and you will have as light bread as though you had used a pint of yeast. It does not take above a quarter of an hour more time than the usual way of baking; for there is no time lost, but that of adding water three or four times. When you find your body of flour spunged large enough, before you put in the rest of the water, you should, with both hands, mix that which is spunged, and the dry flour, altogether, and then add the remainder of warm water, and your dough will rise the better and easier. The author asserts, that he constantly bakes this way; in the morning about six or seven o'clock, he begins his first operation; in an hour's time he adds more water; in two hours more a greater quantity; about noon makes up the dough, and about six in the evening, it is put into the oven; and that he has always good bread, never heavy, nor bitter. He adds, that the cause of heavy bread is not owing to the smallness of the quantity of yeast used, but to its not being used properly, for yeast is to flour what fire is to fuel—a spark of the latter will kindle a large body by only blowing it up; so a thimble full of the former, by adding warm water to it, will raise or spunge almost any quantity of flour.

Thus heavy bread is not owing to a deficiency of fermentation; for, if the dough is put into the oven before it is ripe, heavy bread is the natural consequence.

In regard to the difference of seasons, he prescribes that in summer the water should be blood warm, and in cold frosty weather as warm as you can bear your hand in it, without making it smart; taking care in winter to cover up your dough.

The great importance of good yeast, to the making of wholesome bread, induces the editor to communicate several receipts which may be depended on. Any one of them will answer, but it may be useful to enable a choice to be made.

1. Boil a pint bowl full of hops, in two quarts of water, to one quart; put eight table-spoonfuls of flour into a pan, and strain the hop water boiling on it; when mixed, it should be thick batter, and when milk-warm, stir in a breakfast-cup of good yeast, pour it into three porter bottles, stopping them with paper; put them in a milk-pan near the fire, and as soon as the mixture rises to the top of the bottles, remove them to the cellar until it subsides, then cork the bottles, and set them on a cool cellar floor, or in an ice-house. In very warm weather, the corks ought to be taken out every day, to let out the carbonic acid air, and the bottles again stopped.

2. Another receipt directs the addition of a table-spoonful of ginger, which is to be boiled with the hops; and the further addition a table-spoonful of brown sugar before the flour is stirred in.

3. *Perpetual Yeast.* Mix one pound of flour with boiling water, to the thickness of gruel, add to it half a pound of brown sugar, mix them well together; put three spoonsful of purified yeast into a large vessel, upon which put the above ingredients, which will soon ferment. Collect the yeast off the top, and put it into a small necked pot, and cover it from the air; keep it in a dry place, and moderately warm. When used in part, replace it with flour made into a thin paste, and sugar, in the former proportion. It will keep for half a year or more. No yeast is necessary except the first time. *Columbian Magazine*, December, 1788.

4. Yeast made after the following receipt, is said to be preferable to any other kind.

Boil twelve clean washed, middle sized potatoes; and at the same time boil, in another vessel, a handful of hops in a quart of water; peel, and mash the potatoes in a marble mortar, pour part of the hop-water, while hot, upon the potatoes, mix them well, and pass them through a sieve; then add the remainder of the hop-water, and half a tea-cupful of honey, beat all well, and add a small portion of leaven to bring on the fermentation. Put the whole in a stone jug, and set it by the fire (in the winter.) All the utensils must be scalded every time they are used, and washed perfectly clean. One tea-cupful of the above potatoe yeast, will answer for two quarts of flour. In summer, the yeast ought to be made every second day.

If we consider the use of yeast in *raising* bread, and the antiquity of *leaven*, and of course the relative properties of each,

and their similarity in effect, a number of circumstances must be considered, in order to comprehend the causes of the phenomena of their action.

If dough, after standing a sufficient time, be baked in the usual way, it forms a loaf full of interstices, but of a taste so sour and unpleasant, that it cannot be eaten. If a small quantity of this old paste, or *leaven*, be mixed with new made paste, the whole begins to ferment in a short time, a quantity of gas is evolved; but the glutinous part of the flour prevents the gas from escaping. The paste therefore swells, and when baked, makes excellent bread.

The antient Gauls, however, in relation to this subject, as mentioned by Pliny, made use of the *barm* that rises on beer, or what we call yeast; and ever since, it has had the preference.

Yeast acts, according to the general theory, and particularly the experiments of Eldin, by means of the carbonic acid gas, which it contains, or evolves in the process; for dough, he observes, when mixed with water impregnated with carbonic acid gas, *raises* as well as with yeast; and he adds, that yeast, deprived of its carbonic acid or fixed air, has no efficacy in raising bread. But however true his experiments and conclusions may appear, there is reason to suppose from what we have formerly said, that yeast although dry, has the effect of raising bread when previously moistened; and hence if it be carbonic acid gas, or some other gas, (which undoubtedly it is,) its formation is dependent on the decomposition of the matter itself. Some ingenious experiments on this subject, were made by our late and ingenious countryman, Dr. Pennington.

YELLOW DYES. See Dyeing. Besides the different modes of communicating the yellow colour, and the preparation of dyes, we will add the following, called Woulfe's yellow colour.

Take half an ounce of pulverized indigo, and mix it in a deep glass vessel, with two ounces of strong spirit of nitre, previously diluted with eight ounces of water, to prevent the indigo from taking fire. Let this mixture stand for a week, and digest it in a sand heat, for one or two hours; adding four ounces of water. The solution is now to be filtered: when mixed with water, in the proportion of one part of the former, to four or five of the latter; and, on adding a little alum, it communicates a durable yellow colour.

There are a great many plants, indigenous to our soil, that are useful in furnishing yellow dyes; such as the *Hydratis Canadensis*, *Quercus Tinctoria*, &c.

YELLOW PIGMENTS *In general.* See Colour Making.

YELLOW INK may be prepared, by previously dissolving a small portion of alum, and gum-arabic in pure water, and then infusing a few grains of dry saffron, in the same solution. It may, likewise, be obtained by slowly boiling two ounces of Avignon, or French berries, in one quart of water, with half an ounce of alum, till one-third of the fluid be evaporated; when two drachms of gum-arabic, one drachm of sugar, and a similar quantity of pulverized alum, are to be dissolved in this liquid

YELLOW SYMPATHETIC INK. See Ink.

YELLOW WEED. See Dyeing.

YELLOW, PATENT, or Turner's. See Lead.

YELLOW, NAPLES. The Naples Yellow (*Gillolino*) is a fine pigment, long prepared at Naples, which has the appearance of an earth, is very friable, heavy, porous, not alterable by exposure to air, and of a pale orange-yellow colour When heated it exhales no sensible vapour, melts when red-hot, but undergoes no other change, except that the colour becomes deeper. Boiling water and acid extract a portion from it, but do not dissolve it entirely.

This pigment (the preparation of which is kept secret) has been examined by several chemists, but no accurate analysis has been made of it. Fougeroux shewed that it was a metallic oxyd, by reducing it with a proper flux, and easily obtained a regulus from it, which consisted of lead and antimony. Beckman and Couret have confirmed this composition. A process which produces a similar pigment, is thus given by Couret. Mix together twelve ounces of cerusse, three ounces of diaphoretic antimony, of alum and sal-ammoniac, each one ounce, heat them for a considerable heat below redness, and afterwards in a red-heat for three hours longer, after which the mass will have acquired a beautiful yellow colour.

Another method of preparing the celebrated Naples yellow, is that of M. Passery, who makes use of the following ingredients, namely antimony, one pound; lead one and an half pounds; alum and common salt, of each one ounce. We have inserted this recipe, on the authority of Mr. Wiegleb; who simply enumerates the articles here stated, without communicating the process of compounding them.

YTTRIA. See Earths.

Z

ZAFFRE. See Cobalt.

ZAFFRE INK. See Ink.

ZINC, or Spelter, *Ores of.* See Ore.

ZINC, *how obtained from its ores.*

The ore, whether calamine or blende, after being raised from the mine, is first dressed, that is it is broken to small pieces, and the galena, pyrites, and other impurities are separated as accurately as possible by hand; it is next calcined at a moderately red heat, in a reverberatory furnace, by which the calamine is deprived of its carbonic acid, and the blende of the most part of its sulphur. It is then washed, by which the lighter earthy parts are separated from the metallic oxyd, which latter, being dried, is intimately mixed with one-eighth of its weight of charcoal, by grinding the ingredients together in a mill, and is now ready to be smelted. The furnace in which the reduction is performed, is a circular one not unlike that of a glass-house, in it are fixed six large earthen pots, about four feet high, and nearly of the same shape as oil-jars: into the bottom of each pot is inserted an iron tube, that passes through the arched floor of the furnace, and dips in a vessel of water placed beneath, while the other end of the tube rises within the crucible, to within a few inches of its top. These crucibles are filled up to the level of the tube, with the mixture of roasted ore and charcoal, the cover of each is very accurately luted on, and the furnace is charged with fuel, by which an intense heat is kept up for several hours. The zinc, as it is reduced, ascends to the top of the pot, in the form of vapour, and there being prevented from escaping, by the closely luted cover it descends through the central iron tube, whence it passes into the water, and is there condensed in small drops. These globules are afterwards melted and cast into ingots, in which state they are brought to market.

Common zinc generally contains a little lead, copper, arsenic, iron, manganese, and probably plumbago, which often considerably impair the quality of the alloys, into which it enters. In order to get rid, in part at least, of these impurities, the common practice is to melt the zinc in a crucible, and then stir into it, by means of a stick or earthen rod, a mixture of sulphur and fat: the latter of these preserves the zinc from oxydation, while the former, uniting with all the metals present, except the zinc, converts them into sulphurets, which rising to the top form a scoria that may be skimmed off: this is to be repeated, as long as any scoria makes its appearance. M. Proust objects to this method as completely ineffectual, and proposes another, which is simply redistilling the zinc in an earthen retort; after the metal has passed over, there remains behind, a mixed mass of oxyds and other impurities. But it is not very obvious how either the arsenic or lead can be thus got rid of, nor does it by any means appear, that the old method is so very nugatory. It would probably be an improvement, first to heat the zinc nearly to melting, in which state it is very easily pulverizable, and having thus reduced it to fine powder, to mix it with about one-fifth of its weight of sulphur, and a little pitch, then to charge an earthen retort with the mixture, to keep it for some time, at a temperature not exceeding that of melted lead, and then to raise it by degrees, till the zinc begins to be volatilized: the contents of the retort being now allowed to cool gradually, the purified zinc would be found at the bottom, covered by a scoria of sulphuret.

If however the zinc is required of extreme purity, take the common sulphate of zinc, (white vitriol of the shops,) dissolve it in hot water, and add a little sulphuric acid and granulated zinc, by this means the copper, arsenic, and the principal part of the iron, will be precipitated. When the acid is saturated, pour off the clear liquor, and evaporate it to dryness; moisten the white salt thus procured with a little nitric acid, and heat it nearly to redness in a crucible; by this the residue of the iron and manganese, will be reduced to the state of insoluble oxyd, and warm water will take up only the pure sulphate of zinc. This is to be decomposed by carbonate of ammonia, and the white precipitate thus obtained, after being washed and calcined, is to be mixed with about one-sixth of charcoal, and reduced by distillation in the usual way.

ZINC, *Ores of, how analized.* See Tests.

ZINC, is a semimetal of a blueish white colour, somewhat brighter than lead; of considerable hardness, and so malleable, as not to be broken with the hammer, though it cannot be much extended in this way. It is very easily extended by

the rollers of the flatting mill. In a temperature between 210° and 300° of Fahr. it has so much ductility, that it can be drawn into wire, as laminated, for which a patent has been obtained by Messrs Hobson and Sylvester, of Sheffield The zinc thus annealed and wrought, retains the malleability it had acquired

When broken by bending, its texture appears as if composed of cubical grains. On account of its imperfect malleability, it is difficult to reduce it in o small parts, by filing or hammering; but it may be granulated, like the malleable metals, by pouring it, when fused, into cold water; or, if it be heated nearly to melting, it is then sufficiently brittle to be pulverized.

It melts long before ignition, at about the 700th degree of Fahrenheit's thermometer; and, soon after it becomes red-hot, it burns with a dazzling white flame, of a blueish or yellowish tinge, and is oxyded with such rapidity, that it flies up in the form of white flowers, called the flowers of zinc, or philosophical wool. These are generated so plentifully, that the access of air is soon intercepted; and the combustion ceases, unless the matter be stirred, and a considerable heat kept up.—The white oxyd of zinc is not volatile, but is driven up merely by the force of the combustion. When it is again urged by a strong heat, it becomes converted into a clear yellow glass. If zinc be heated in closed vessels, it rises without decomposition. Zinc appears to be the most volatile of metallic substances, except arsenic.

The diluted sulphuric acid dissolves zinc: at the same time that the temperature of the solvent is increased, and much hydrogen escapes, an undissolved residue is left, which has been supposed to consist of plumbago. Proust, however, says, that it is a mixture of arsenic, lead, and copper. As the combination of the sulphuric acid, and the oxyd proceeds, the temperature diminishes, and the sulphate of zinc, which is more soluble in hot than cold water, begins to separate, and disturb the transparency of the fluid. If more water be added, the salt may be obtained in prismatic four-sided crystals. The white vitriol, or copperas, usually sold, is crystallized hastily, in the same manner as loaf-sugar, which on this account it resembles in appearance: it is slightly efflorescent. The white oxyd of zinc is soluble in the sulphuric acid, and forms the same salt as is afforded by zinc itself.

The hydrogen gas, that is extricated from water, by the action of sulphuric acid, carries up with it a portion of zinc, which is apparently dissolved in it; but this is deposited spontaneously, at least in part, if not wholly by standing. It burns with a brighter flame than common hydrogen

Sulphate of zinc, or white vitriol, is prepared in the large way from some varieties of the native sulphuret. The ore is roasted, wetted with water and exposed to the air. The sulphur attracts oxygen, and is converted into sulphuric acid; and the metal, being at the same time oxyded, combines with the acid. After some time the sulphate is extracted by solution in water; and the solution being evaporated to dryness, the mass is run into moulds. This, the white vitriol of the shops, generally contains a small portion of iron, and sometimes of lead

Sulphurous acid dissolves zinc, and sulphuretted hydrogen is evolved. The solution, by exposure to the air, deposits needly crystals, which, according to Fourcroy and Vauquelin, are sulphuretted sulphite of zinc. By dissolving oxyde of zinc in sulphurous acid, the pure sulphite is obtained. This is soluble, and crystallizable.

Diluted nitric acid combines rapidly with zinc, and produces much heat, at the same time that a large quantity of nitrous air flies off. The solution is very caustic, and affords crystals by evaporation and cooling, which slightly detonate upon hot coals, and leave oxyde of zinc behind.—This salt is deliquescent.

Muriatic acid, acts very strongly upon zinc, and disengages much hydrogen; the solution, when evaporated, does not afford crystals, but becoms gelatinous. By a strong heat it is partly decomposed, a portion of the acid being expelled, and part of the muriat sublimes and condenses in a congeries of prisms.

Zinc is soluble in other acids; but these combinations are not used in the arts. Besides uniting with different acids, it combines with some of the inflammables, and with other metals. Although we have noticed one of its combinations, namely, brass, yet we deem it useful, to a portion of our artists, to give a more practical treatise on the subject of the brass foundery. This very important alloy of zinc and copper, is treated at large in several excellent works. Messrs. Aikins, in their Chemical and Mineralogical Dictionary, have enumerated several processes, and have added some useful observations, which we here use.

It is not easy to obtain a perfect union of zinc and copper by mere fusion in open vessels, for at a heat less than is required

to melt the copper, the zinc readily takes fire, and much of it burns off before it has time to mix with the metal, so that the proportion of zinc is constantly lessening by volatilization. Even after both metals are fused, the zinc continues to burn off in uncovered vessels, and at last scarcely any thing but copper would be left. In order therefore to combine copper most intimately with zinc, and yet to preserve its malleability, the ingenious process of cementation has been resorted to, in the manufacture of brass, which is performed by heating in a covered pot, alternately layers of copper in small pieces, with zinc ore and charcoal, and continuing the fire till the copper is thoroughly impregnated with the zinc.

Zinc being a volatile metal, can only be procured from its ores by sublimation: the process for obtaining it (which is described more at length under that article) being to heat strongly a mixture of its ore with charcoal, in a vessel closed on all sides, except where it admits a tube, the lower end of which dips in water. As soon as the charcoal reduces the oxyd, the metal rises in vapour through the tube, and condenses in the water below. A similar reduction takes place in brass-making, only the vapour of the zinc, instead of being conveyed out of the crucible in which it is formed, unites with the copper enclosed in the same vessel, and the whole melts down into brass. A less heat is required in brass-making, than that which fuses copper, the zinc being able to penetrate the copper when thoroughly red hot, and melting it down as soon as it becomes brass.

Brass is manufactured in many countries.

The ores of zinc, are several species of calamine and of blende, called by the miners Black Jack.

These are chiefly oxyds, or carbonated oxyds of zinc, and require a previous calcination before they are fit for brass making.

At Holywell, in Flintshire, the calamine which is received raw from the mines in the neighbourhood, is first pounded in a stamping mill, and then washed and sifted in order to separate the lead, with which it is largely admixed. It is then calcined on a broad, shallow brick hearth, over an oven heated to redness, and frequently stirred for some hours. In some places a conical pile is composed of horizontal layers of calamine, alternating with layers of charcoal, the whole resting on a layer of wood, in large pieces, with sufficient intervals for the draught of air. It is then kindled, and the stack continues to burn till the calamine is thoroughly calcined. The calamine thus prepared, is then ground in a mill, and at the same time mixed with about a third or a fourth part of charcoal, and is then ready for the brass furnace. In some places pit-coal is ground with the calamine, instead of charcoal, but this is found to injure the malleability of the brass obtained.

The brass-furnace has the form of the frustum of a hollow cone, or a cone with the apex cut off horizontally. At the bottom of the furnace is a circular grate, or perforated iron plate, coated with clay and horse-dung, to defend it from the action of the fire. The crucibles stand upon the circular plate, forming a circular row with one in the middle. The fuel, which is coal, is thrown round the crucibles, being let down through the upper opening or smaller end of the cone. Over this opening is a perforated cover made of fire-bricks and clay, and kept together with bars of iron, so as to fit closely. This cover serves to regulate the heat in the following manner: The draught of air is formed through an under-ground vault to the ash hole, thence through the grate and round the crucibles, and through the smaller upper opening into an area, where the workmen stand, which is covered by a large dome, and a chimney to convey the smoke into the outer air. When the draught is the strongest, and the heat is required of the greatest intensity, the cover is entirely removed and the flame then draws through the upper opening of the furnace to a considerable height, into the outer brick dome; when the heat is to be lessened, the cover is put on, which intercepts more or less of the draught from the furnace, as more or fewer of the holes of the cover are left unstopped.

The crucibles are charged with the mixed calamine and charcoal, together with copper clippings and refuse bits of various kinds, and sometimes brass clippings also, most of which are previously melted and run into a small sunk cistern of water, through a kind of cullender, which divides the metal into globules, like shot. Powdered charcoal is put over all, and the crucibles are then covered and luted up with a mixture of clay, or loam, and horse-dung.

The time required for heating the crucibles, and compleating the process, varies considerably in different works, being determined by custom, by the quantity of materials, the size of the crucibles, and especially the nature of the calamine. In the great way, from ten to twenty-four

hours are required. At Holywell, in Flintshire, about twenty-four hours are taken.

During the process, and especially towards the latter end, part of the reduced zinc which escapes absorption by the copper, finds it way in vapour through the luting of the crucible lids, and burns around them with the beautiful blue flame, and dense white smoke, peculiar to this metal.

The heat required for brass-making is somewhat less than what would be necessary to melt large masses of copper, brass being the more fusible of the two, and, as it should seem, the vapour of zinc being able to penetrate copper, as soon as it is softened by a full red heat. When the brass is judged to be complete, and the saturation of the copper with zinc to be as high as possible, the heat is increased to melt the whole down into one clean mass at the bottom, the crucibles are taken out and the metal poured into moulds. At Holywell, out of the six crucibles used to one furnace, the quantity of brass obtained, is about as much as would fill one of them. This makes in subsequent manufacture, a single large plate, which is manufactured in the same way as copper-plate. Or, more accurately, from forty pounds of copper, and sixty pounds of calamine, about sixty pounds of brass are obtained, besides the loss of a good deal of zinc, by the unavoidable escape of much of it in form of vapour through the pores of the lute or the crucible covers.

The above is the usual process of brass making, and is essentially the same wherever this alloy is manufactured, but with some variation as to the choice of ingredients, their proportions, the time of fusion, the shape of the furnace, and other smaller circumstances.

At Goslar, in Saxony, where brass is largely made, the zinc is furnished, not by a native calamine, but the *cadmia*, or sublimed oxyd of zinc, which is collected for this purpose in a particular part of the chimnies of the reverberatory furnaces, in which the Saxon lead ores and blendes are roasted.

A great variety obtains in the respective proportions of the ingredients. According to Swedenborg, they are, in Goslar, 30 parts of copper, 40 to 45 of cadmia, and twice the volume of charcoal; at Paris, and in many of the French manufactories, they are, 35 of copper, 35 of old brass, 40 of calamine, and 20 to 25 of charcoal; in Sweden, 30 of copper, 20 to 30 of old brass, and 46 of calamine, with charcoal sufficient; or, 40 of copper, 30 of old brass, and 60 of calamine; and in England, generally about 40 of copper and 60 of calamine. The product of brass varies also, but it seems to be in few places so great as in some of the English works, where, as already mentioned, 40 pounds of copper become in the process 60 pounds of brass. This superior quantity is ascribed partly to the goodness of the calamine, and partly to the smallness to which the copper is previously reduced by being poured melted into cold water, and thus affording a great surface of metal to the action of the zinc vapour.

At Stolberg, near Aix-la-Chapelle, where brass is very largely manufactured, the furnaces are cylindrical, and each contains eight crucibles arranged in two tiers, of four each. These crucibles are fifteen inches high, twelve inches deep, and eight or nine inches wide. The proportions of ingredients are forty pound of copper, sixty-five pound of calamine, and double its volume of charcoal. After the fire has been kept up for twelve hours, the crucibles are uncovered, and a workman takes off, with an iron trowel, all the scum and charcoal, which swim upon the liquid metal, and which is called arkest. When examined with a glass, this is found to consist of calamine and copper particles, cohering together, but not completely united. The brass resulting from this process is coarse, brittle, and unequal in texture, and requires a second fusion before it is fit for use. For this purpose the same crucibles are employed, and are filled, first with three handfuls of the mixture of calamine and charcoal, over which are put two or three pounds of the impure brass, broken in pieces, then more calamine and charcoal, with a lump of the arkest, and over all, calamine and charcoal powder. The crucible is then strongly heated for two hours, after which the brass is fit to be cast into plates, which is done here in the following manner. A mould is formed of two blocks of granite, five feet long, three and a half broad, and eight inches thick. They are placed one above the other, the upper one being only moveable, and furnished with a tackle and pullies for that purpose, and before casting, the surface is smeared with cow-dung. To give the plate the requisite thickness, hoops of iron, of different dimensions, are adapted to the under stone, so as to confine a determinate quantity of melted metal. The stones are then gently inclined, and the melted brass let in between them. These plates are afterwards laminated—some of them are cut into slips by strong shears, for the further purpose of being drawn into wire, and otherwise manufactured in various ways.

A single process, where the fire is kept up long enough, and the materials are good, is certainly sufficient to make good malleable brass, but it is probable that the excellence and beauty of the article, are improved by making it undergo a second cementation, with fresh calamine and charcoal.

In the laboratory, brass may be made very well, in the small way in a much shorter time. Put into a crucible a mixture of calamine and charcoal, bury it in the requisite proportion of copper shot, cover the whole with charcoal powder, lute on a cover to the crucible, and heat slowly in a wind-furnace for half an hour, till the zinc begins to burn off in a blue flame, round the top of the crucible, then raise the fire and heat briskly, for half an hour longer.

This process of cementation is also neatly shown by the following management, as given by Cramer. Put the mixture of calamine and charcoal into a crucible, cover it with a thin layer of clay, over which when dry, lay a thin plate of copper, cover the whole with fine charcoal powder, and lute on a cover to the crucible. Apply heat gradually, and the vapour of the reduced zinc, will rise through the floor of clay, penetrate the red-hot copper plate above it, and gradually convert it into brass, which at the end of the operation, will be found lying melted on the stratum of clay. The increase of weight gained by the copper in this operation will afford a good practical test of the goodness of the calamine, and its fitness for brass-making in the great way.

The most important properties of brass compared with copper, are the following: the colour of brass is much brighter, and more approaching to that of gold; it is more fusible than copper; less subject to rust, and to be acted on by the vast variety of substances which corrode copper, with so much ease; and it is equally malleable when cold, and more extensible than either copper or iron, and hence is well fitted for fine wire. Brass however is only malleable when cold. Hammering is found to give a magnetic property to brass, perhaps, however, only arising from the minute particles of iron beaten off the hammer, during the process, and forced into the surface of the brass, but this circumstance makes it necessary to employ unhammered brass for compass-boxes, and similar apparatus.

Some kinds of very fine brass, are said not to be made by cementation, in the way already described, but by a more speedy and direct union of copper and zinc, care being taken to prevent the access of air, to the materials while in fusion. Very fine brass may also be made, by mixing together the oxyds of copper and zinc, and reducing them with a carbonaceous flux. This idea is ingenious, and from the intimate mixture of the two metals, which it promises, it deserves to be further pursued. Sage gives the following experiment, to this purpose. Mix together 50 grains of the oxyd of copper, remaining after the distillation of verdigris, (which is very pure) with 100 grains of lapis calaminaris, 400 grains of black flux, and 30 grains of charcoal powder; melt the mixture in a crucible till the blue flame is seen no longer round the lid of the crucible, and when cold, a fine button of brass is found beneath the scoria, weighing a sixth more than the copper alone, obtainable from its oxyd in the same way, but without the calamine. This brass has a very fine colour like gold. See Alloys of Copper.

Zinc is used in China as coin, and is employed as a substitute for tin, in lining vessels.

An useful substitute for white-lead, in painting houses, has lately been discovered in zinc, by M. de Morveau. He directs this mineral to be calcined in a crucible, placed horizontally in the cavity usually made for retorts, in reverberatory furnaces. The oxyd thus obtained, is then to be washed in water, with a view to separate such particles, as may not have been perfectly calcined; and when it is reduced to powder, a small portion of earth of alum, or chalk, must be added; in order to give it a body. When this pigment is to be used, it will be necessary to form the powder into a heap, leaving a small hole in the middle, into which oil must be gradually poured, till it be reduced to a proper consistence; when the paint should be laid on, with a soft brush. The whitest drying oil must be procured, such as that obtained from poppies, if a white paint be designed; because coloured oil imparts a tinge, that impairs its whiteness; but, if a yellowish or other shade be intended, any drying oil will answer the purpose. M. Morveau observes, that such paint is perfectly harmless, emitting no hurtful effluvia; and though it does not dry so speedily, as that prepared of white-lead, yet it is not only more wholesome, but also eventually cheaper; as a smaller portion of zinc will be required.

In March, 1796, a patent was granted to Mr. John Atkinson, for his invention of a white paint, prepared from zinc, which may serve as a substitute for that of white-lead. He directs the former mineral to

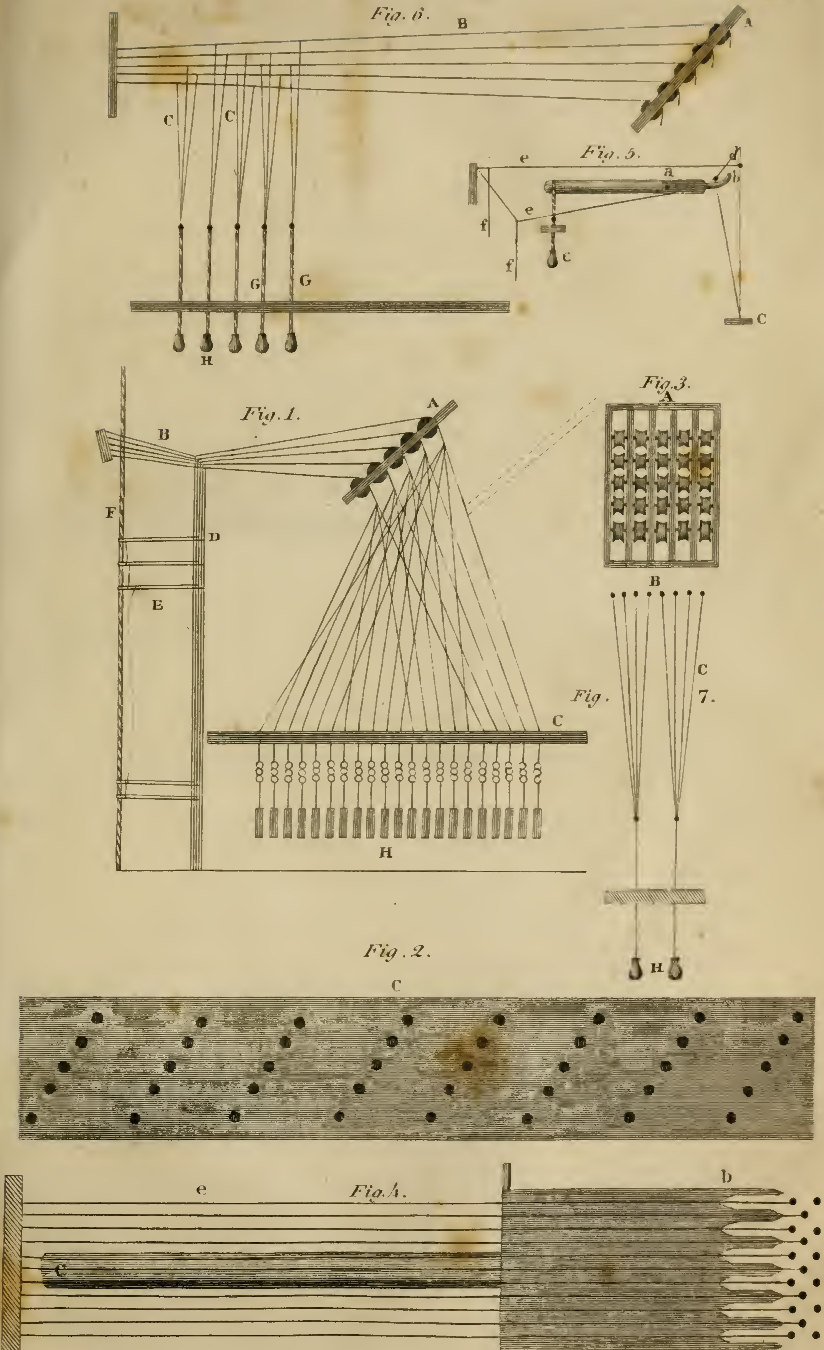
be first submitted to a reverberatory furnace, for six hours ; in order to disperse all the ferruginous particles which it may contain. Next, the zinc is to be reduced to powder, by the action of a mill, and mixed with one-eighth part of pulverized charcoal, by weight ; after which it must be removed to a close or muffled furnace, provided with two apertures, one on each side, "and (as the patentee expresses himself,) dilated at the end from the furnace, by a distance of about 20 feet ;" the other end joining the body of the furnace: such apertures should each be furnished with a door at the farthest extremity, and which ought to be sufficiently large to admit a man to enter, for the purpose of collecting the colour. Thus the zinc must be introduced into the furnace, through the top or upper part: when it becomes red-hot throughout, a large dense white cloud, with a bright blue flame, will pass into the receptacles or apertures above-mentioned, where it will collect in the form of a pure, white metallic calx.

The oxyd of zinc is now to be diluted with water, and ground and triturated in a proper mill: from this machine it is conducted, by means of gutters or spouts into fine sieves, whence it passes into several cisterns full of water, communicating with each other, by similar gutters ; so that the finest particles float into the farthest reservoirs. After standing about 24 hours, the water may be drawn off, and the colour collected into pans, receivers, or other vessels, capable of bearing heat, in which they are dried ; and in this state, the paint will be ready for sale ; but previously to its application, it ought to be properly levigated.

According to M. Rinman, a fine green colour for painters may be procured, from the oxydes of cobalt and zinc. He directs any portion of cobalt-ore to be dissolved in the nitro-muriatic acid (AQUA REGIA) and to be mixed with half that quantity of nitrat of zinc : a lixivium of pot-ash is then to be added ; and when the precipitate is ignited to whiteness, it will be fit for use.

ZIRCON. See EARTHS.

FINIS.



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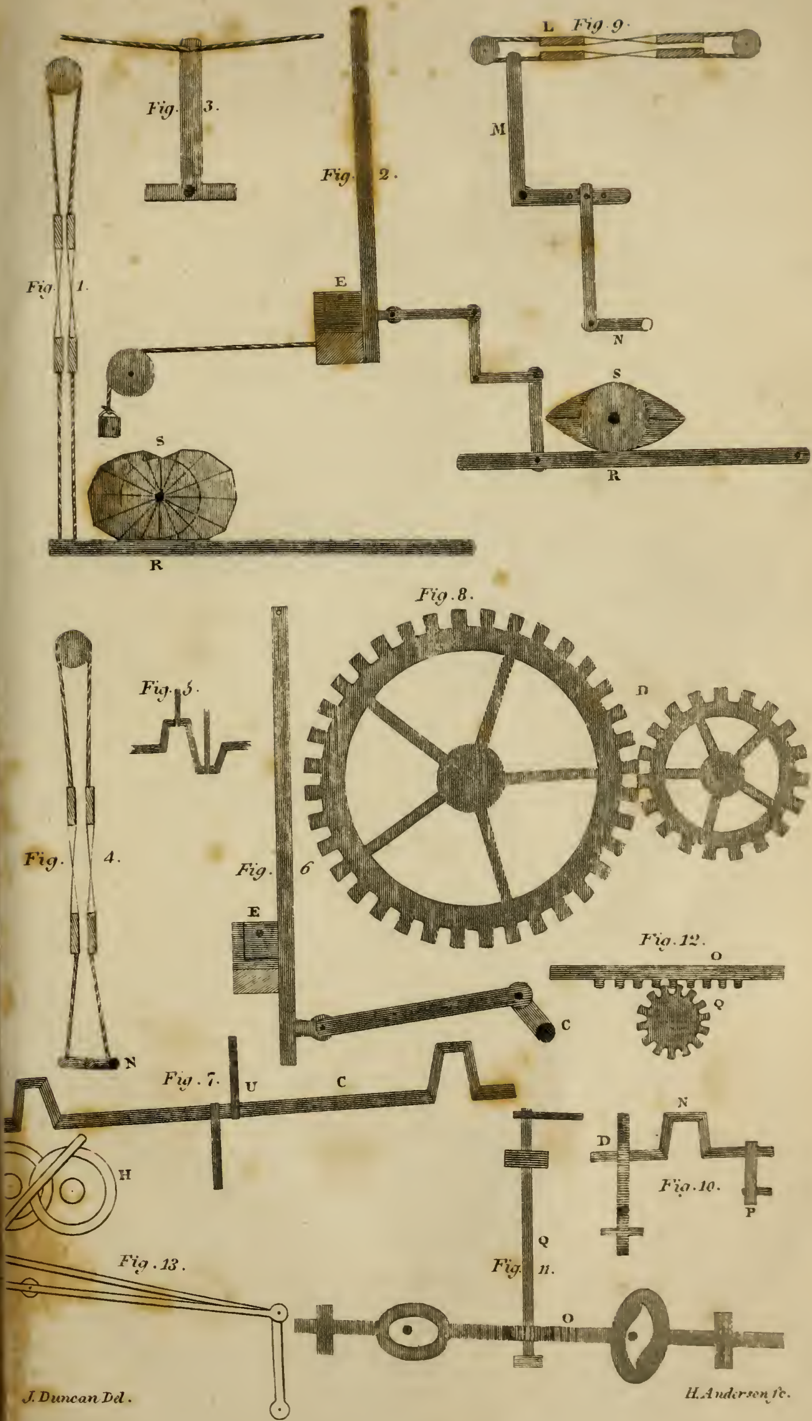

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Weaving.

Plate 23.

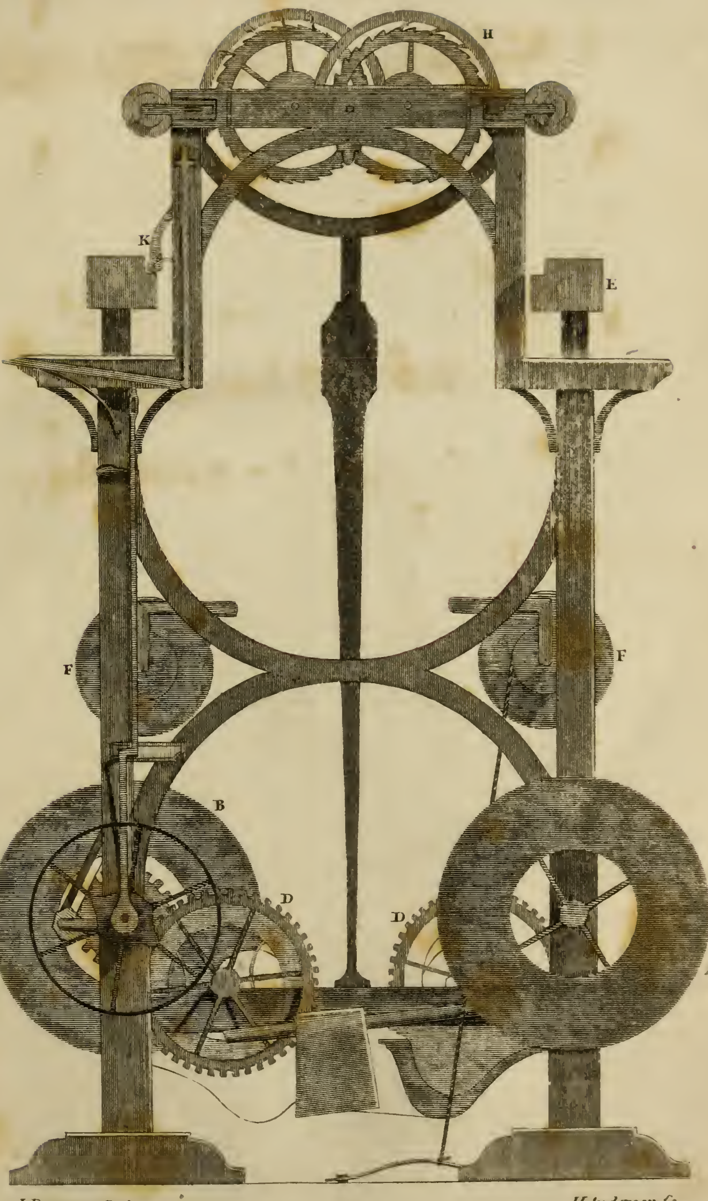

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Fig. 1.

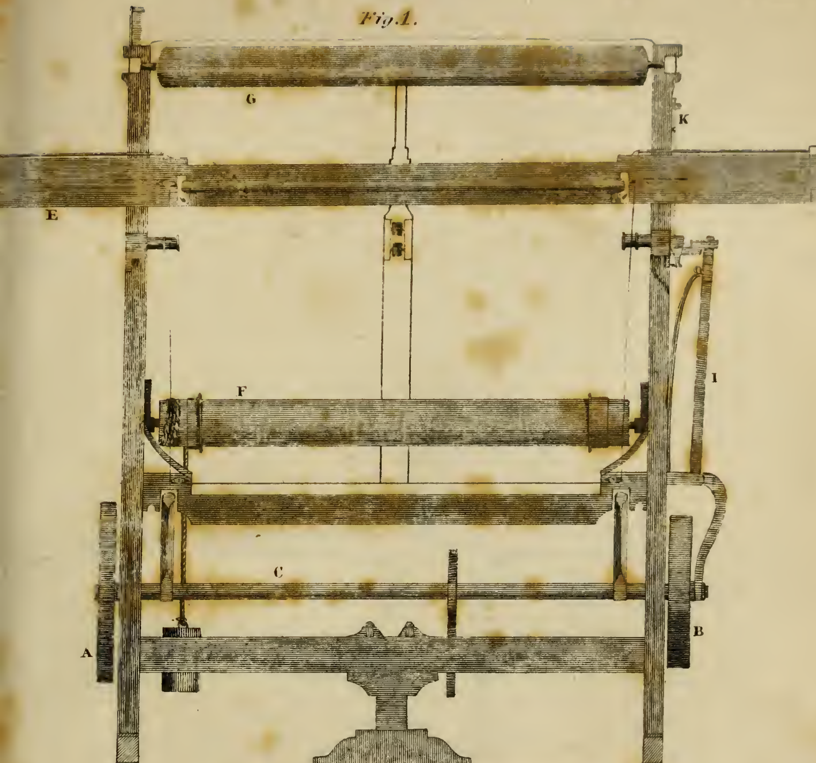

Fig. 4.

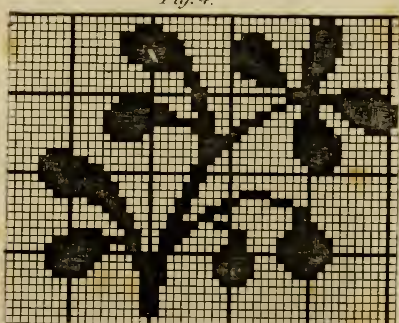

Fig. 3.

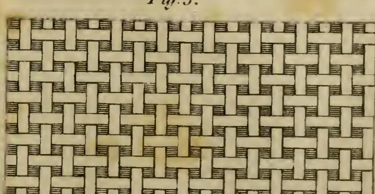

Fig. 2.

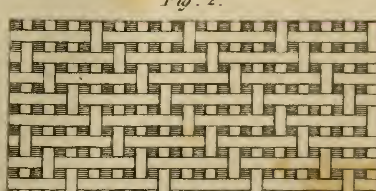

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TABLE

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